Trigger Angle Dependence of Near- and Away-side Jet Shape with respect to the Reaction Plane at mid-p_T region with a special emphasis on Left / Right Asymmetry

--- Left / Right Medium Asymmetry w.r.t. Jet Axis ---

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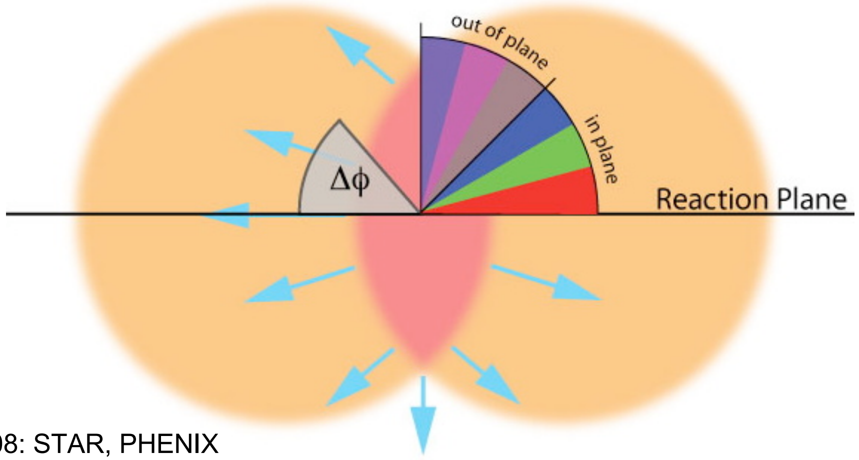
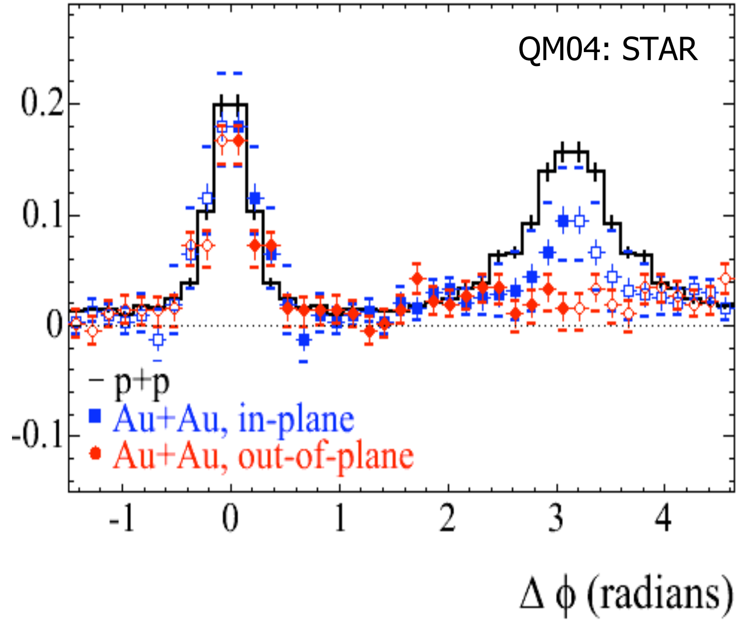
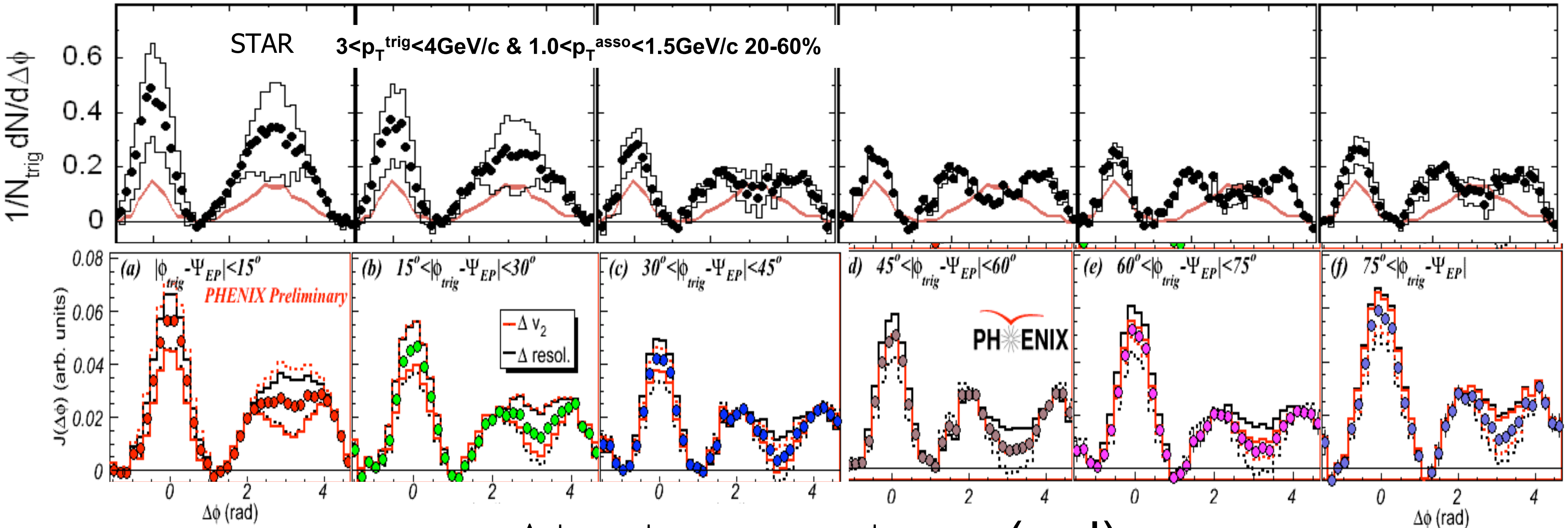
University of Tsukuba
筑波大学

Previous results #1



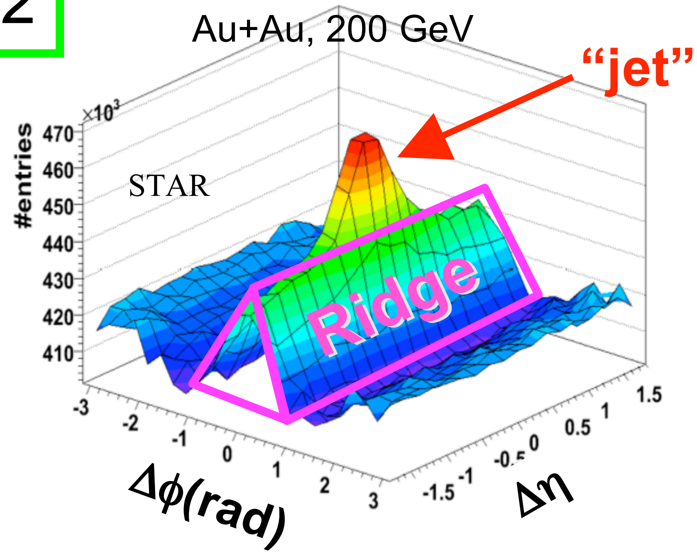


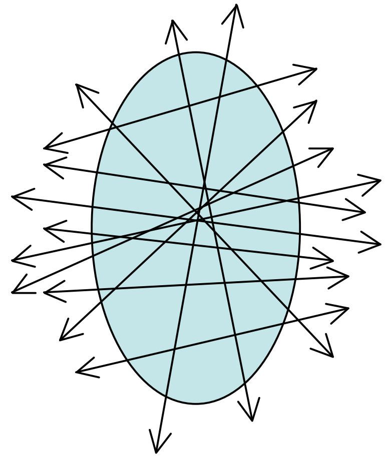
QM08: STAR, PHENIX



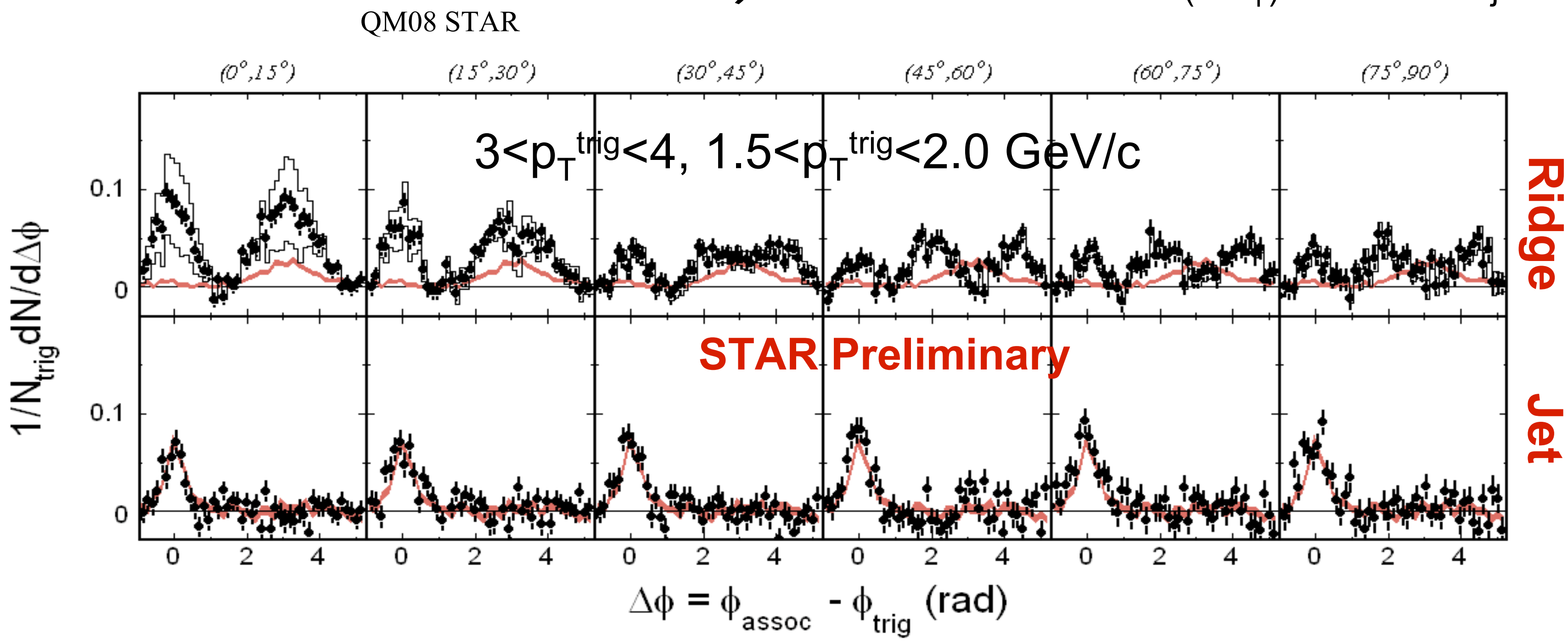
$$\Delta\phi = \phi_{associate} - \phi_{trigger} \text{ (rad)}$$

Previous results #2

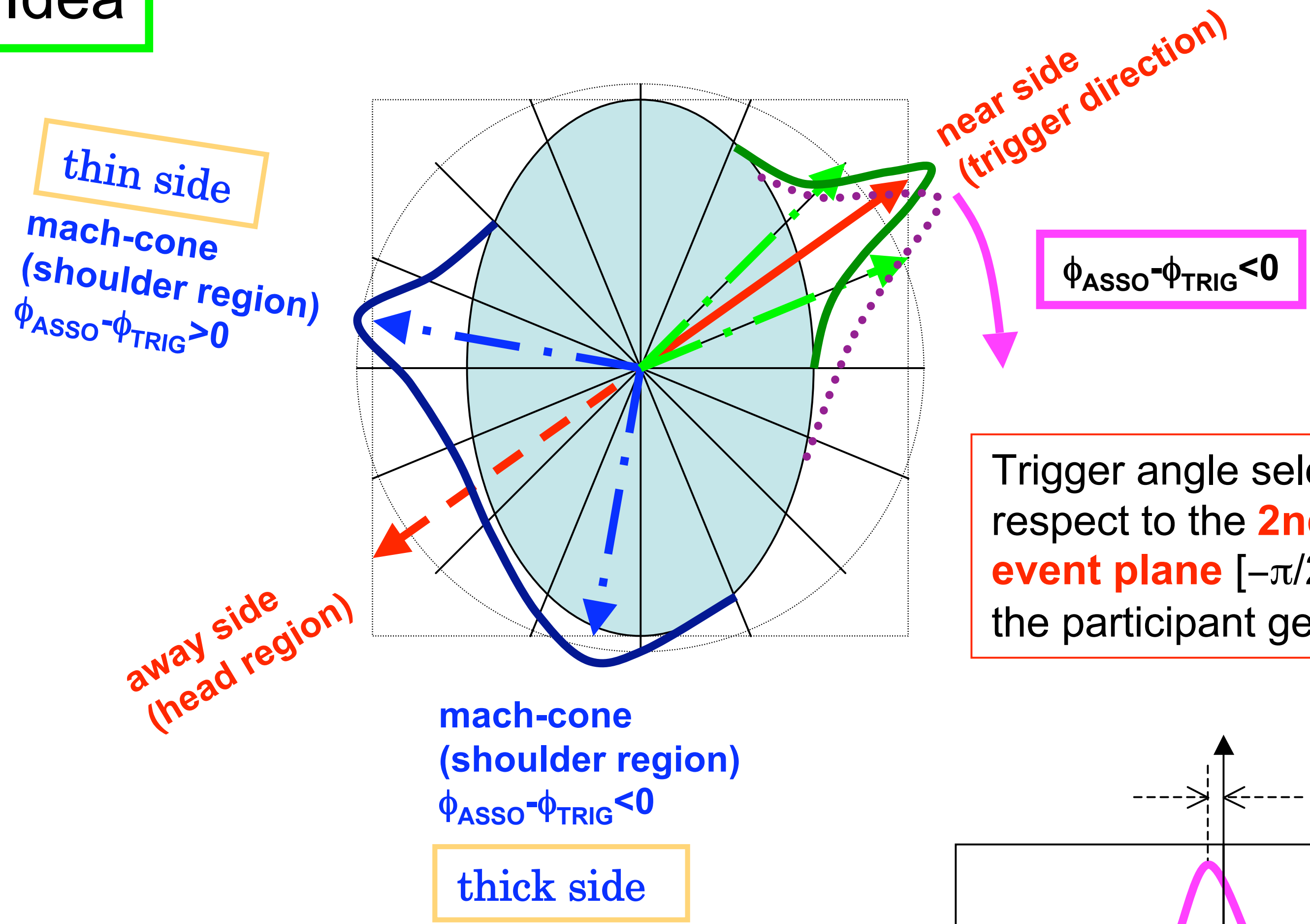




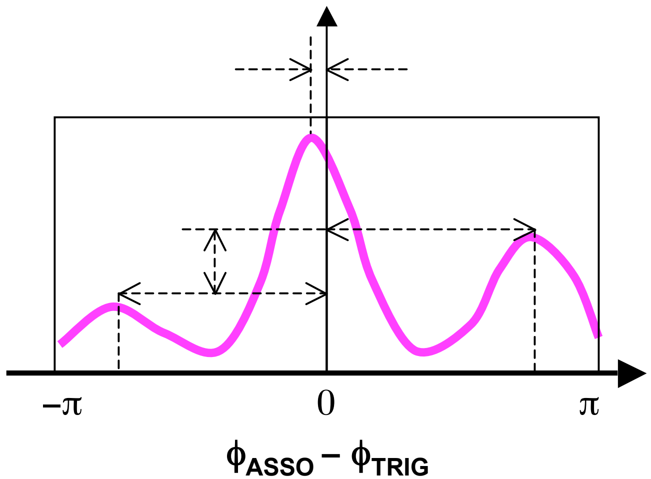
away side (in dφ) of one di-jet can be near side (in dφ) of another di-jet



New Idea



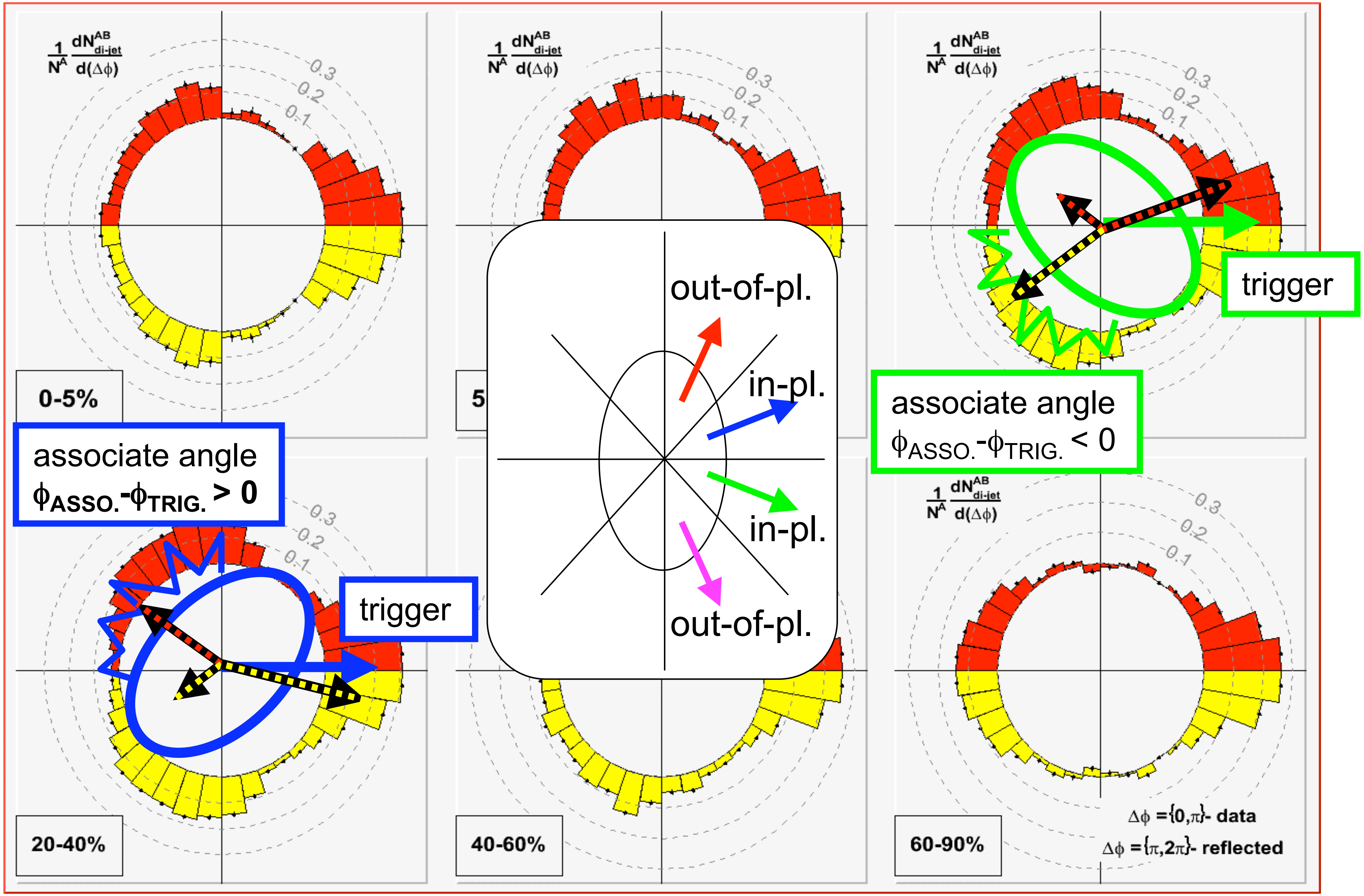
Trigger angle selected with respect to the **2nd moment event plane** [–π/2,π/2] to probe the participant geometry



If trigger angle is fixed around +/–(π/4), the associate particles emitted left or right w.r.t. trigger direction would feel the different thickness of the almond. It is because the almond shaped medium is asymmetric w.r.t. jet axis.

turn the page!

Understanding of Mach-cone shape of (p_T^{Asso}=1~2GeV/c)
with trigger angle selected 2-particle correlration (p_T^{Trig}=2~4GeV/c)



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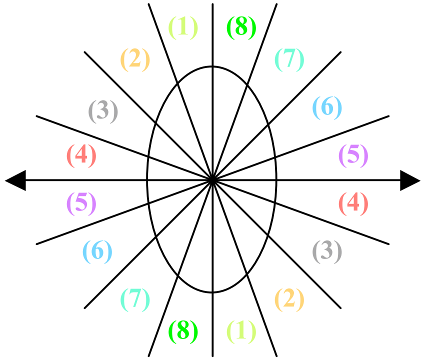
Analysis methods



RUN7, Au+Au 200GeV 30-40%, h-h

$2 < p_T^{trig.} < 4\text{GeV/c}$

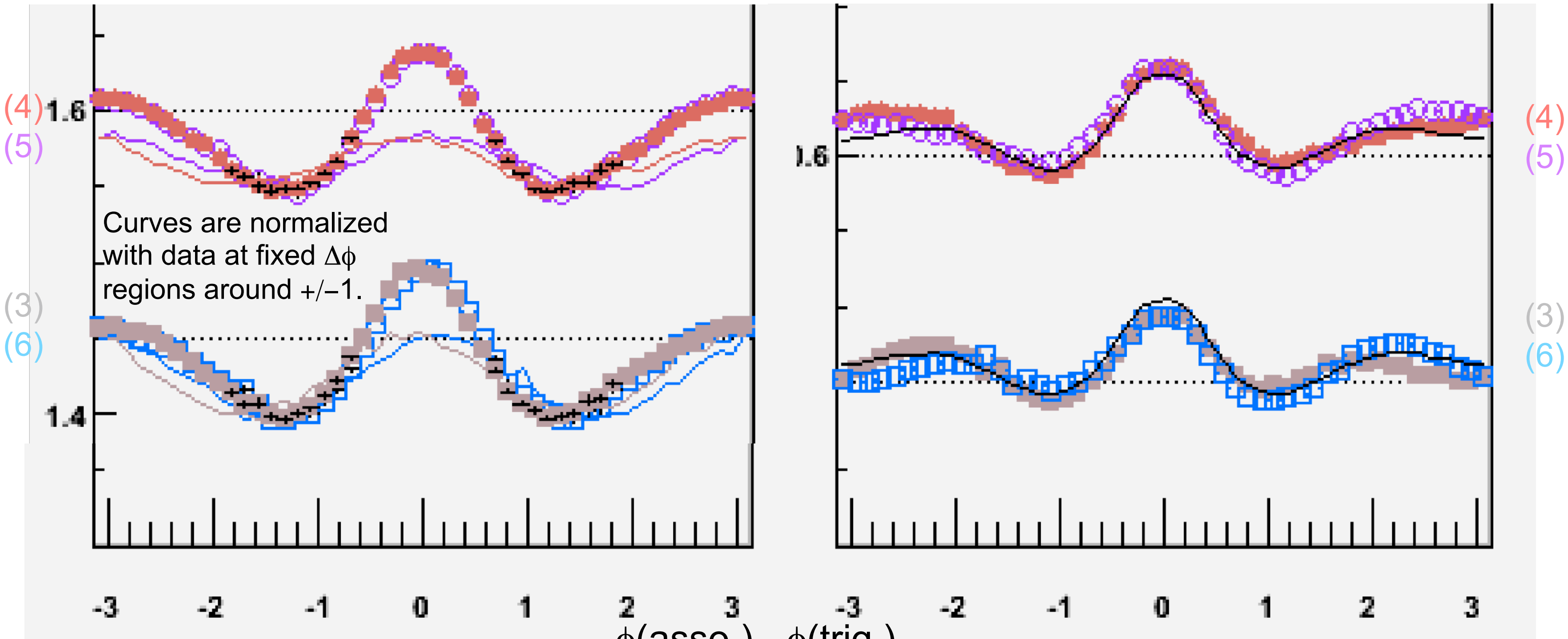
$1 < p_T^{asso.} < 2\text{GeV/c}$

C_2 = (Real pair) / (Mixed pair)

$J = C_2^{data} - C_2^{mc}$

before flow subtraction

after flow subtraction



ϕ(asso.) - ϕ(trig.)

Colored lines are expected flow curves, which are given by MC with measured v2,v4 and R.P. resolution.

Black lines are reference curves, which are given by the average of all (1)~(8) data.

turn the page!

Analysis methods

RUN7, Au+Au 200GeV 30-40%, h-h
$2 < p_T^{trig.} < 4$GeV/c
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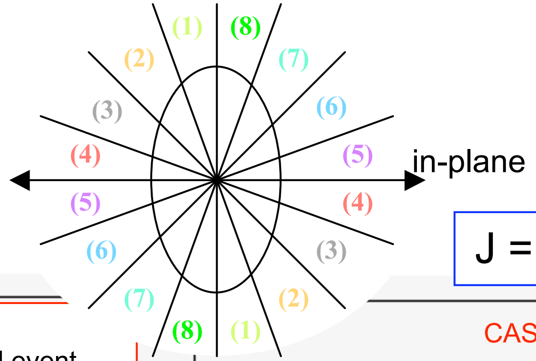
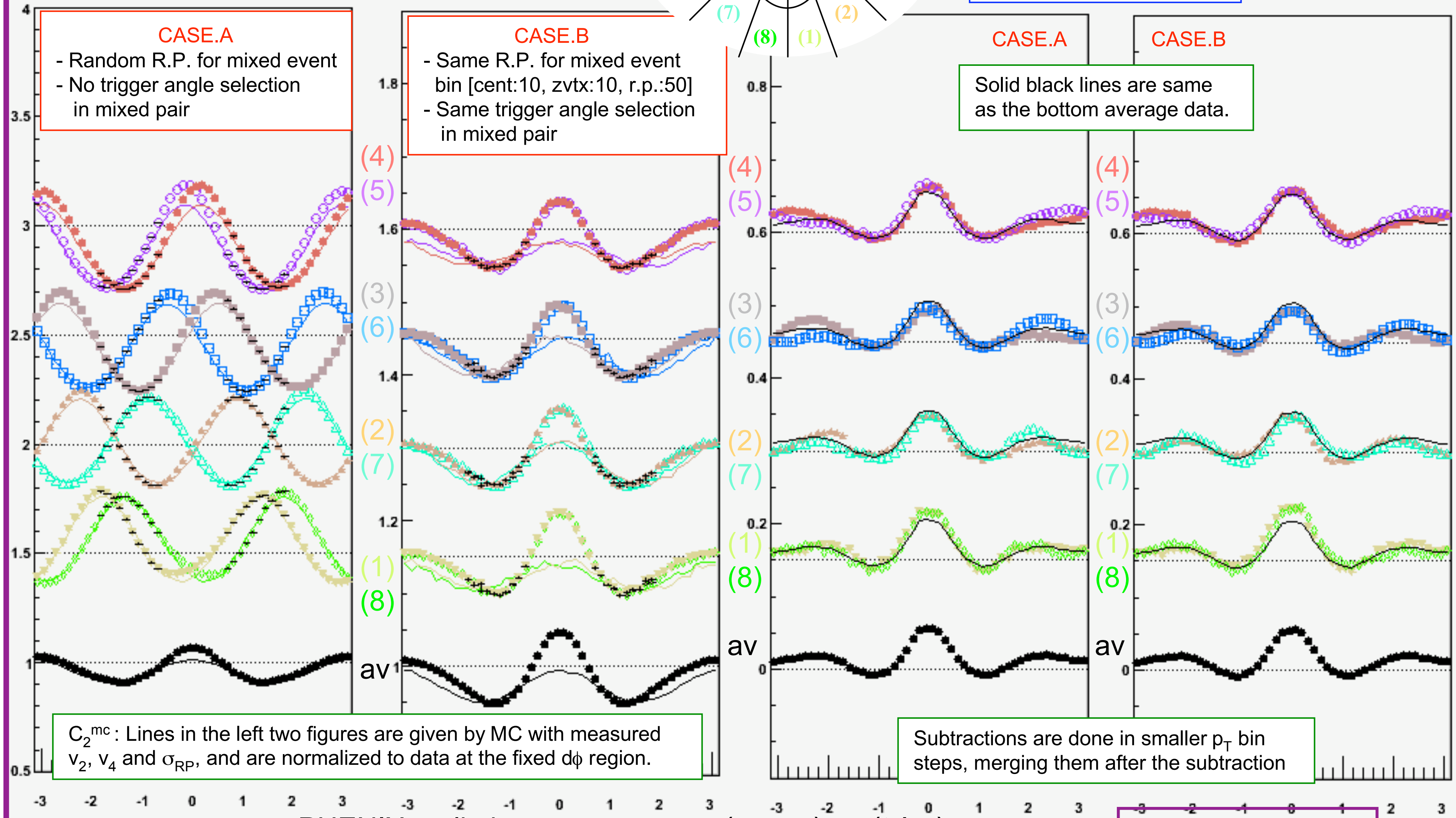


C_2 = (Real pair) / (Mixed pair)

$J = C_2^{data} - C_2^{mc}$



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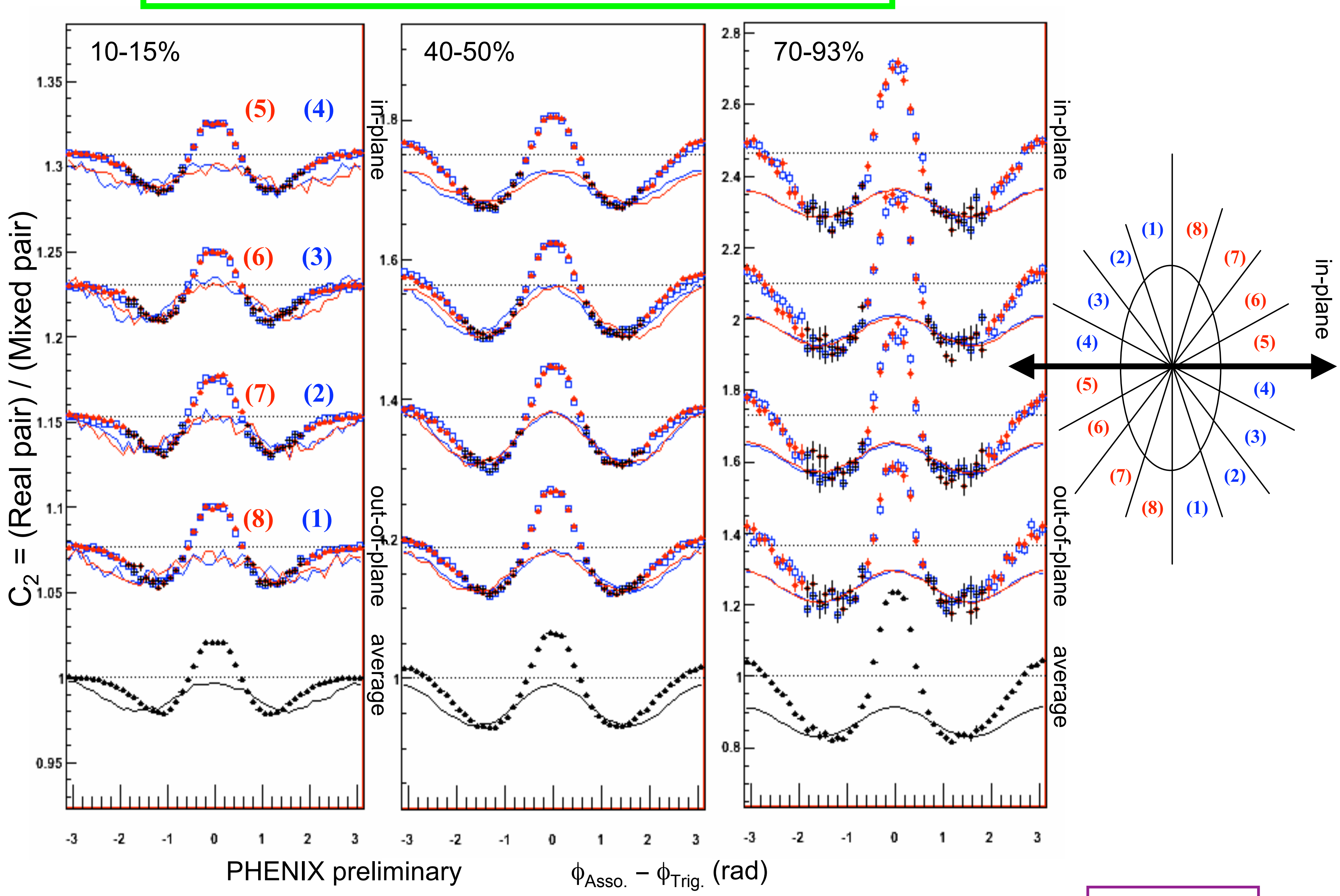
ϕ(asso.) - ϕ(trig.)

under the prev. page

correlation functions before the flow subtraction



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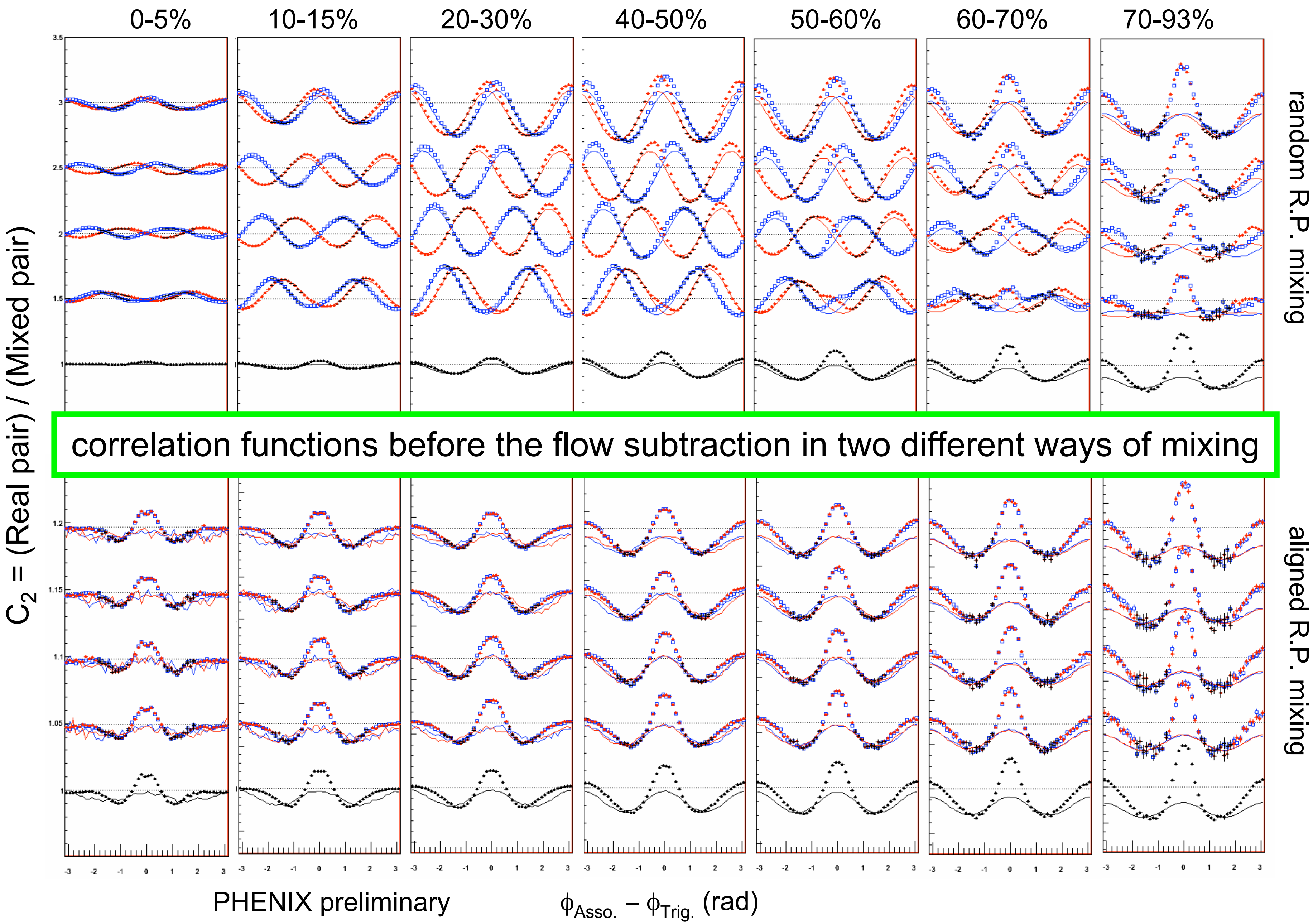

correlation functions before the flow subtraction in two different ways of mixing

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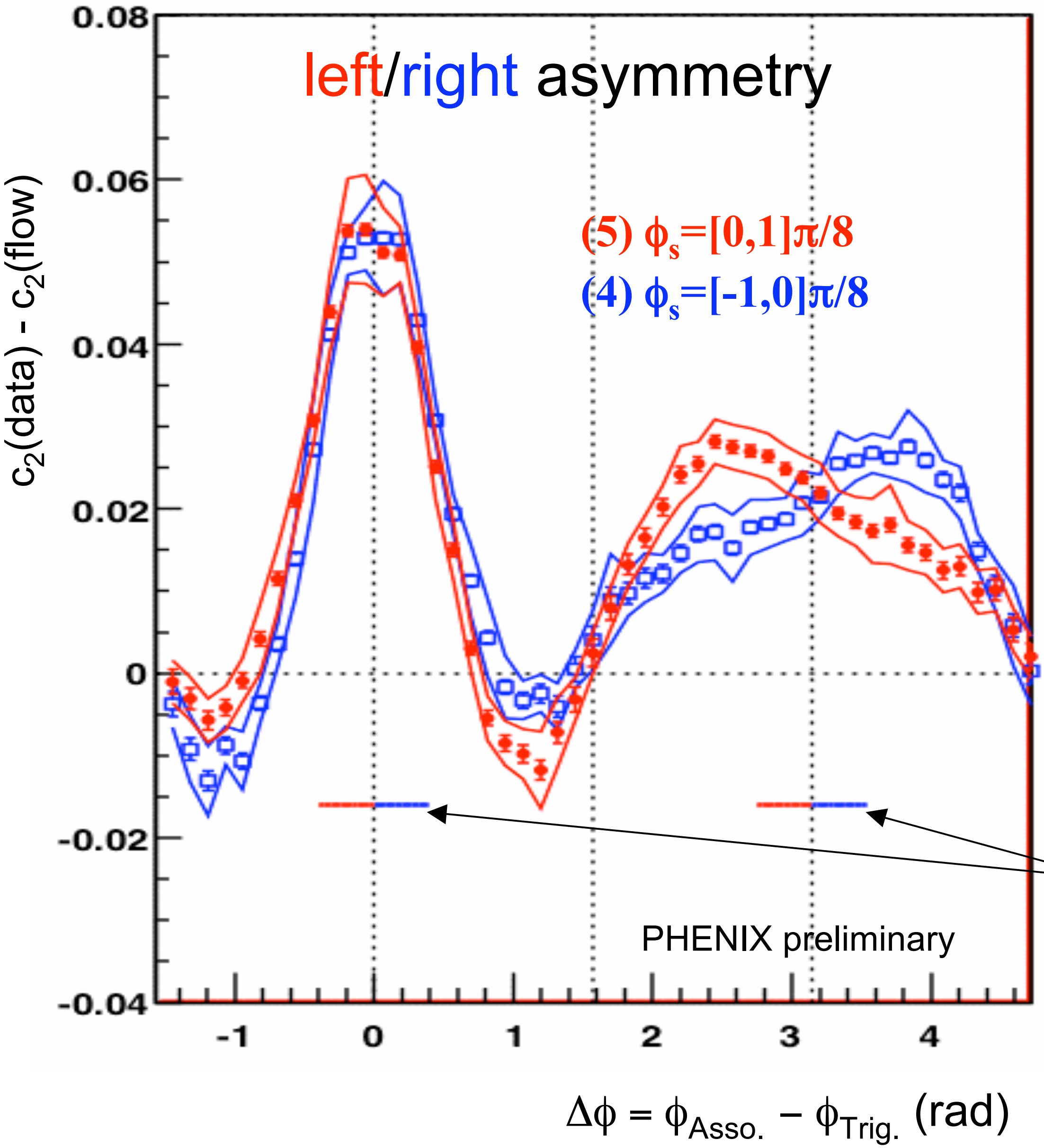
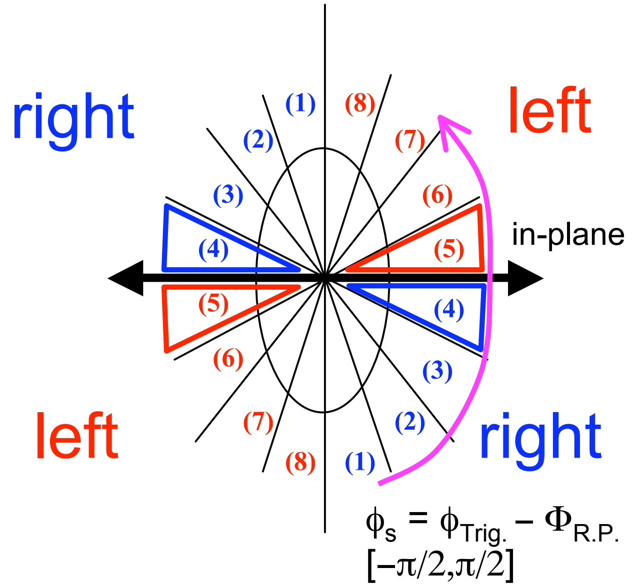
Results #1 (mid-central)



200GeV Au+Au -> h-h (run7)

(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

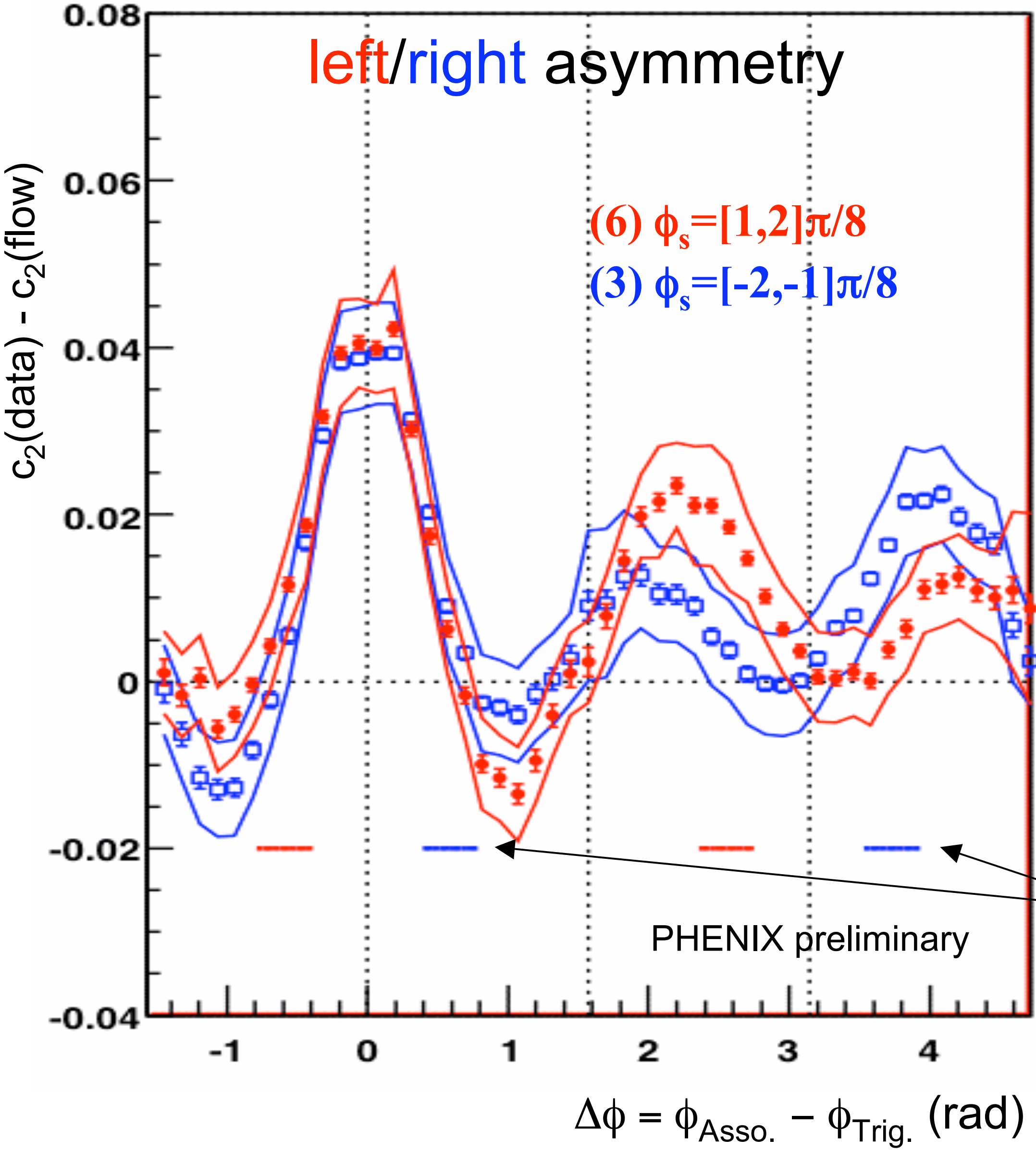
mid-central : 20-50%



in-plane associate regions

turn the page!

Results #2 (mid-central)



200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)
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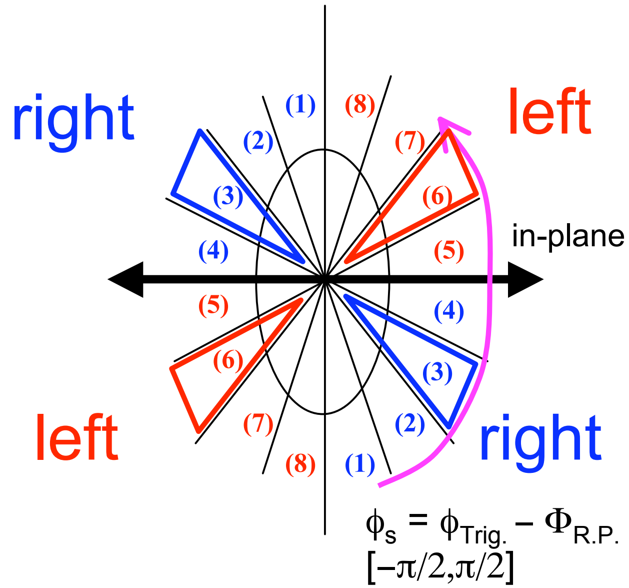
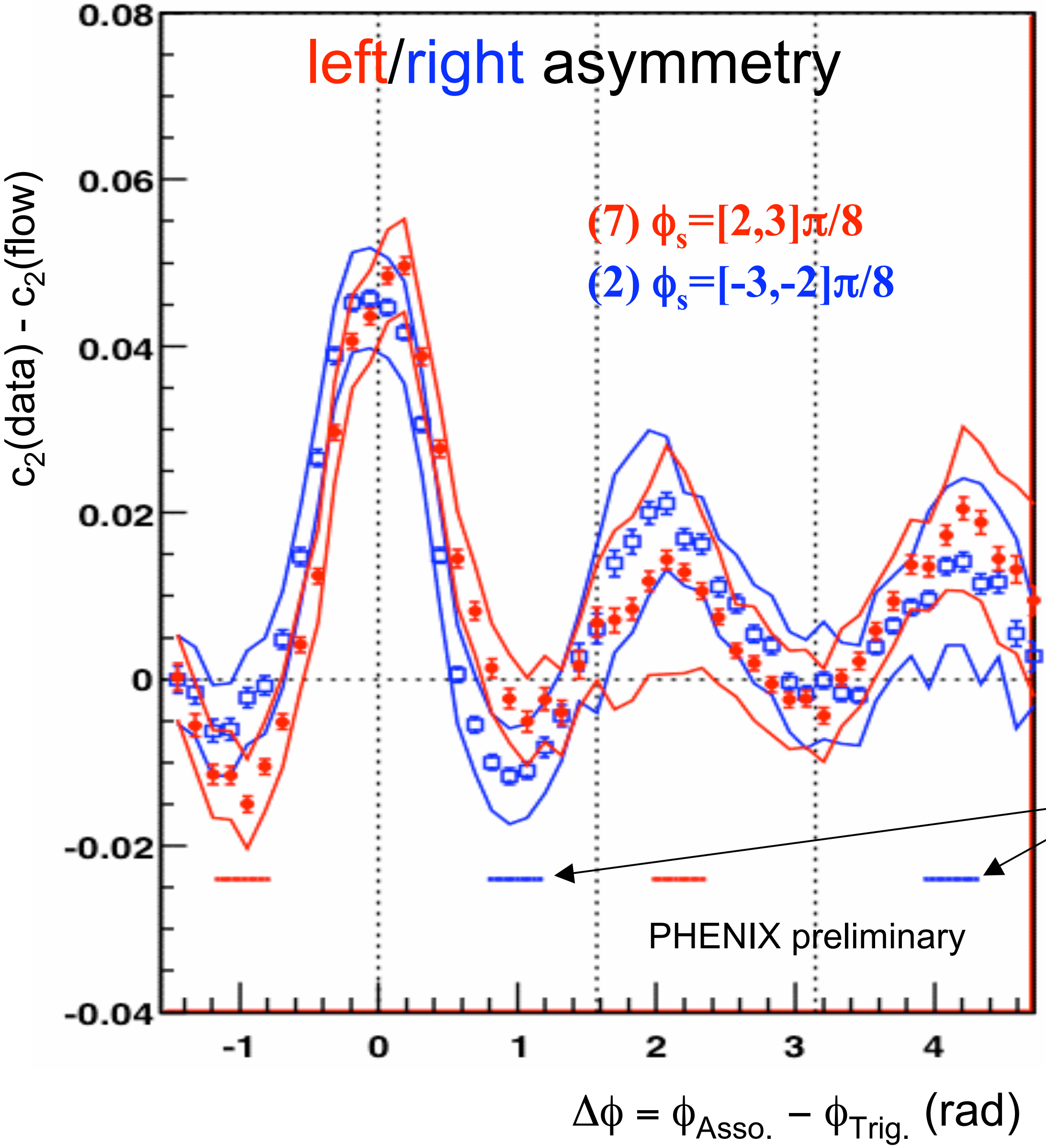


in-plane associate regions

under the prev. page

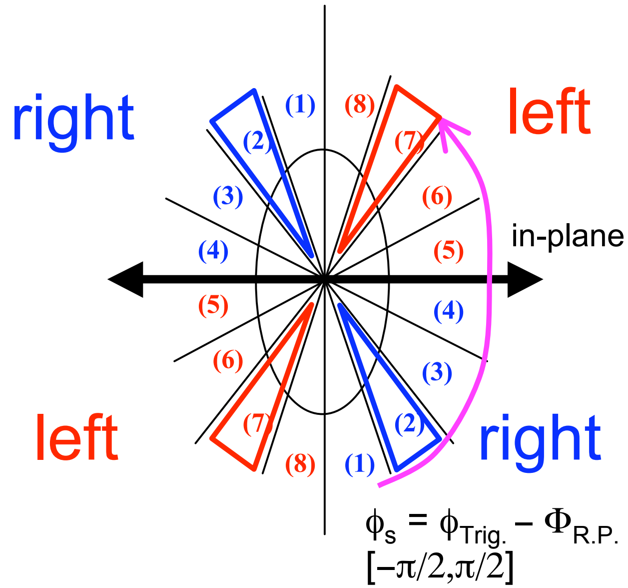
Results #3 (mid-central)



200GeV Au+Au -> h-h (run7)

(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

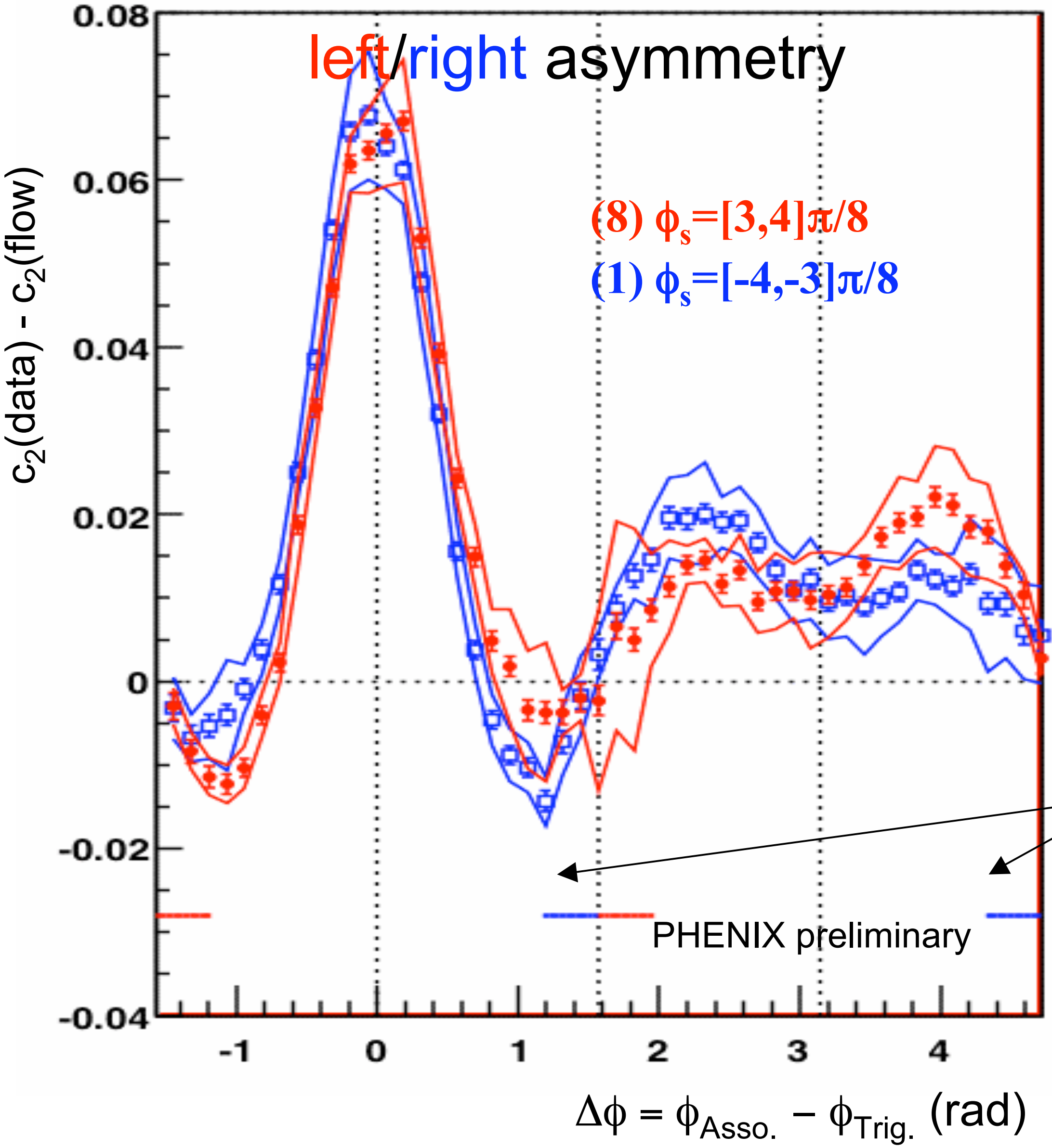
mid-central : 20-50%



in-plane associate regions

under the prev. page

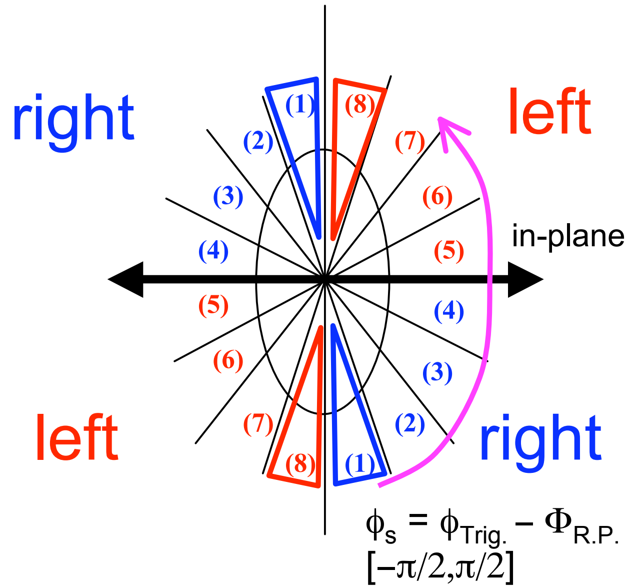
Results #4 (mid-central)



200GeV Au+Au -> h-h (run7)

(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

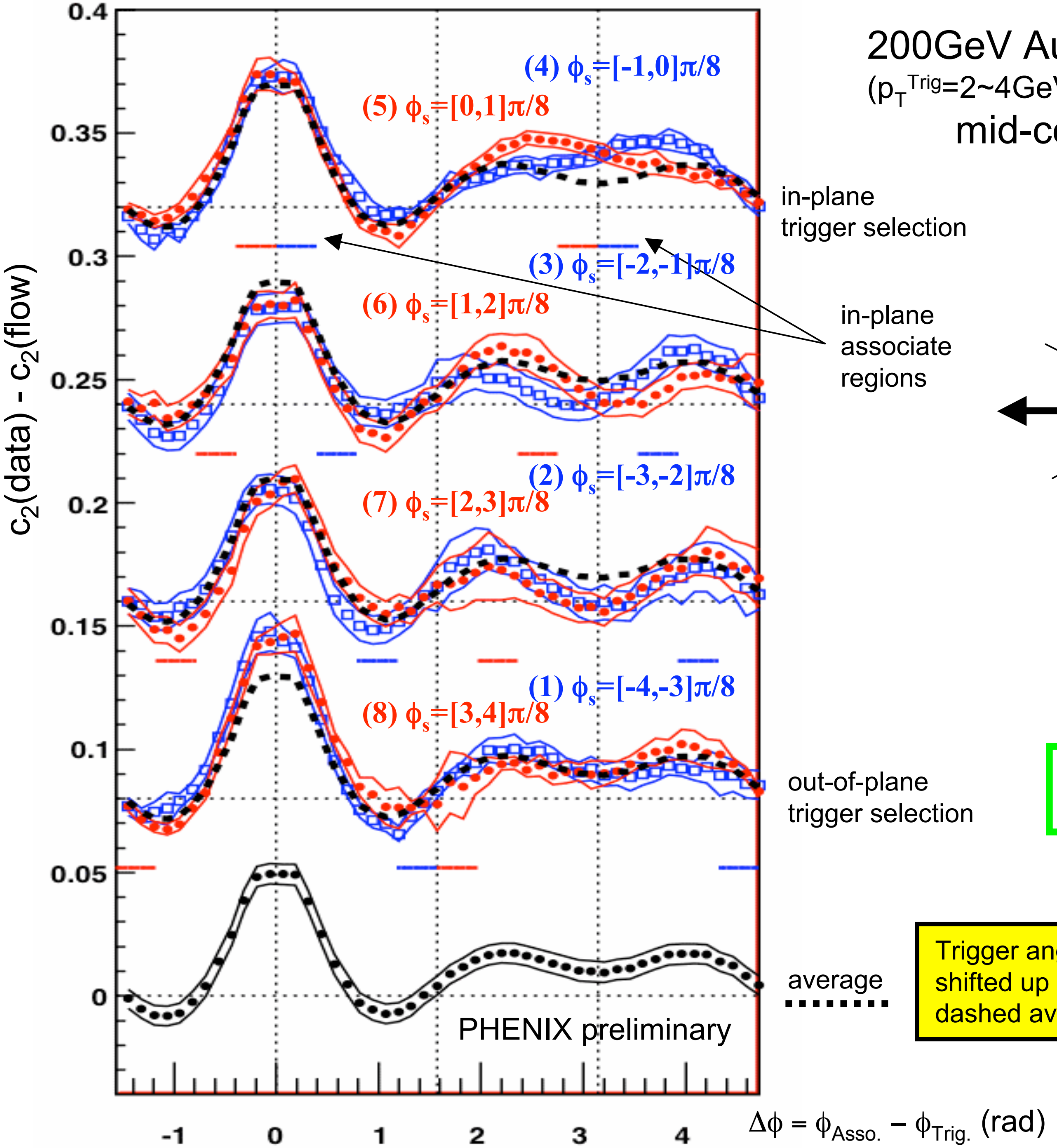
mid-central : 20-50%

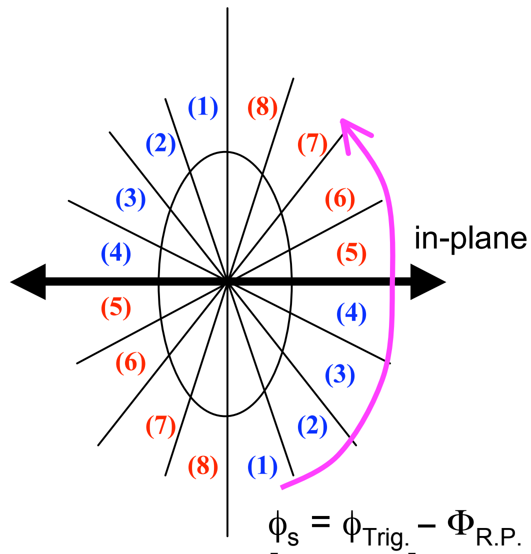


in-plane associate regions

under the prev. page

200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)
mid-central : 20-50%





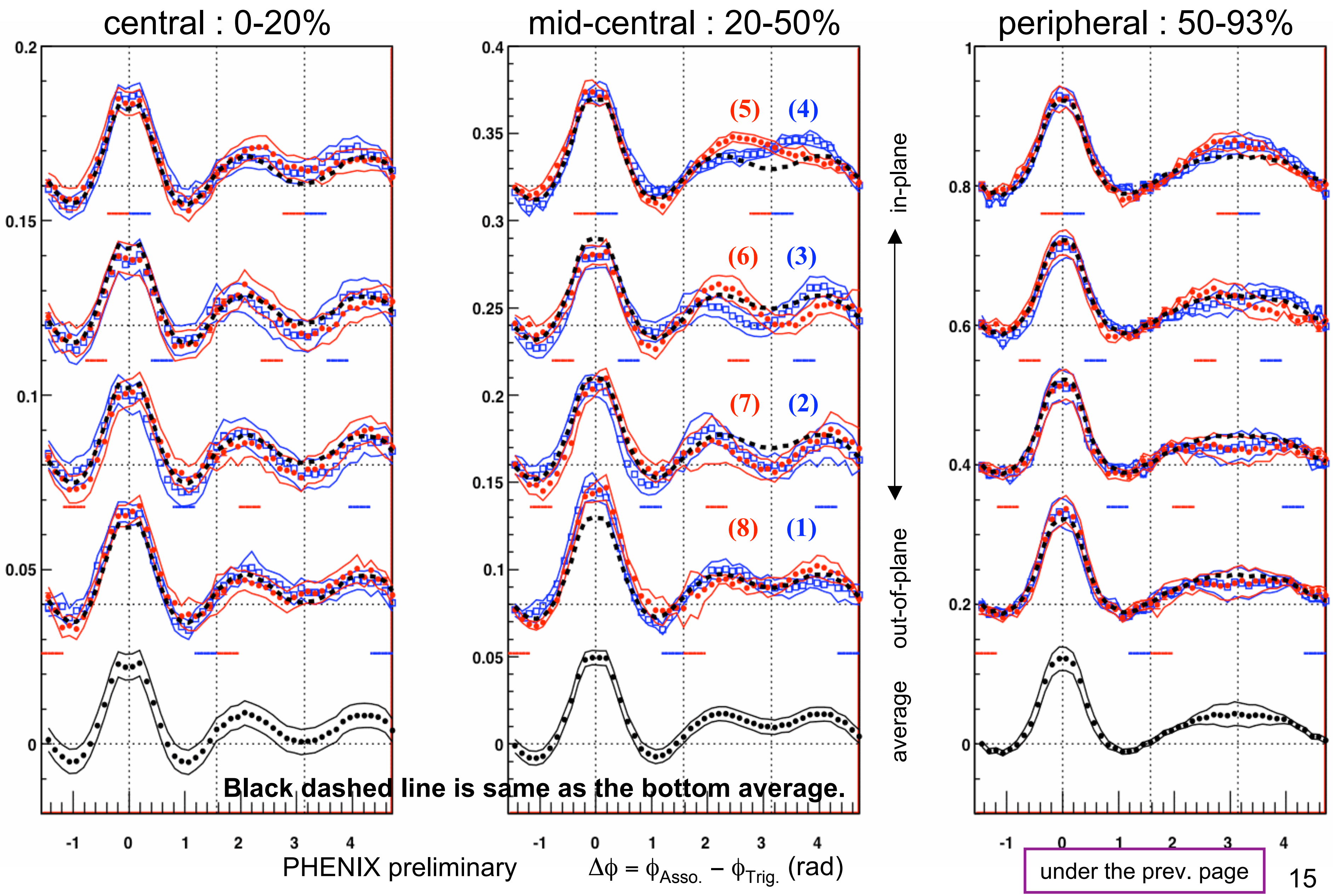
$\phi_s = \phi_{Trig.} - \Phi_{R.P.}$
$[-\pi/2, \pi/2]$

Results #1~4

Trigger angle selected curves are shifted up by constant offsets, dashed average lines are overlaid.

turn the page!

200GeV Au+Au -> h-h (run7)(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)



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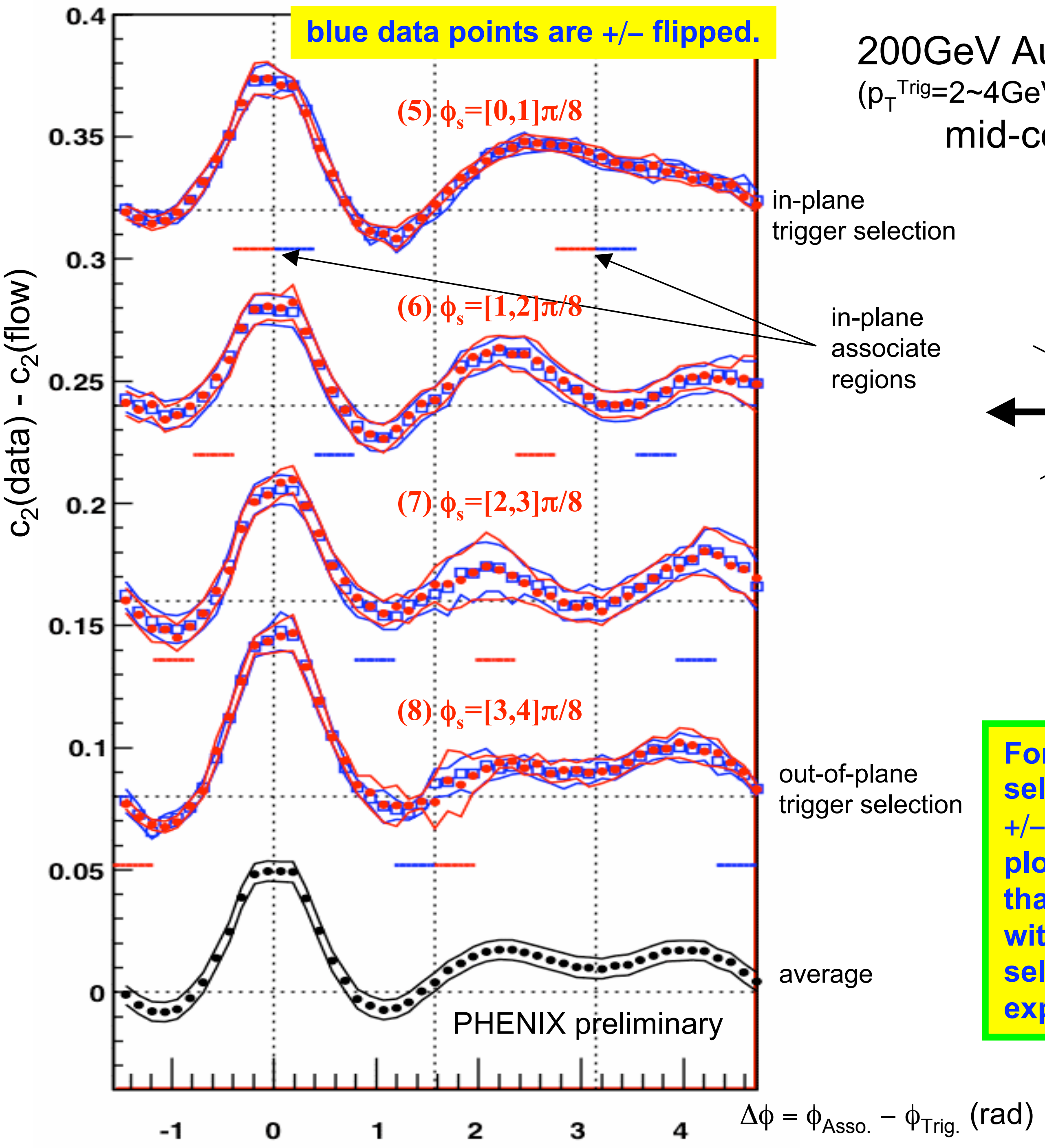
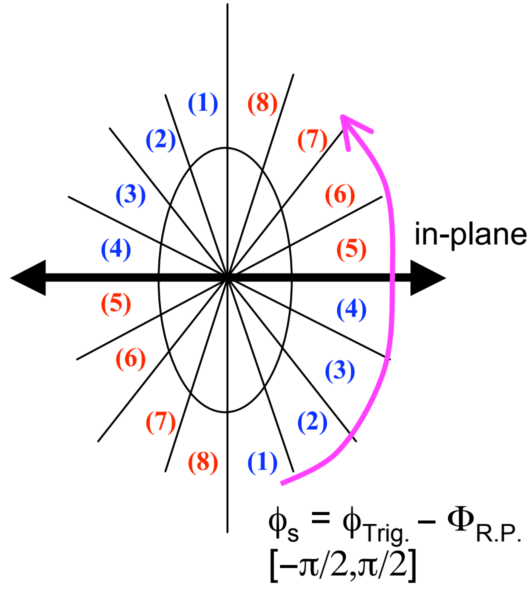
200GeV Au+Au -> h-h (run7)

(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

mid-central : 20-50%

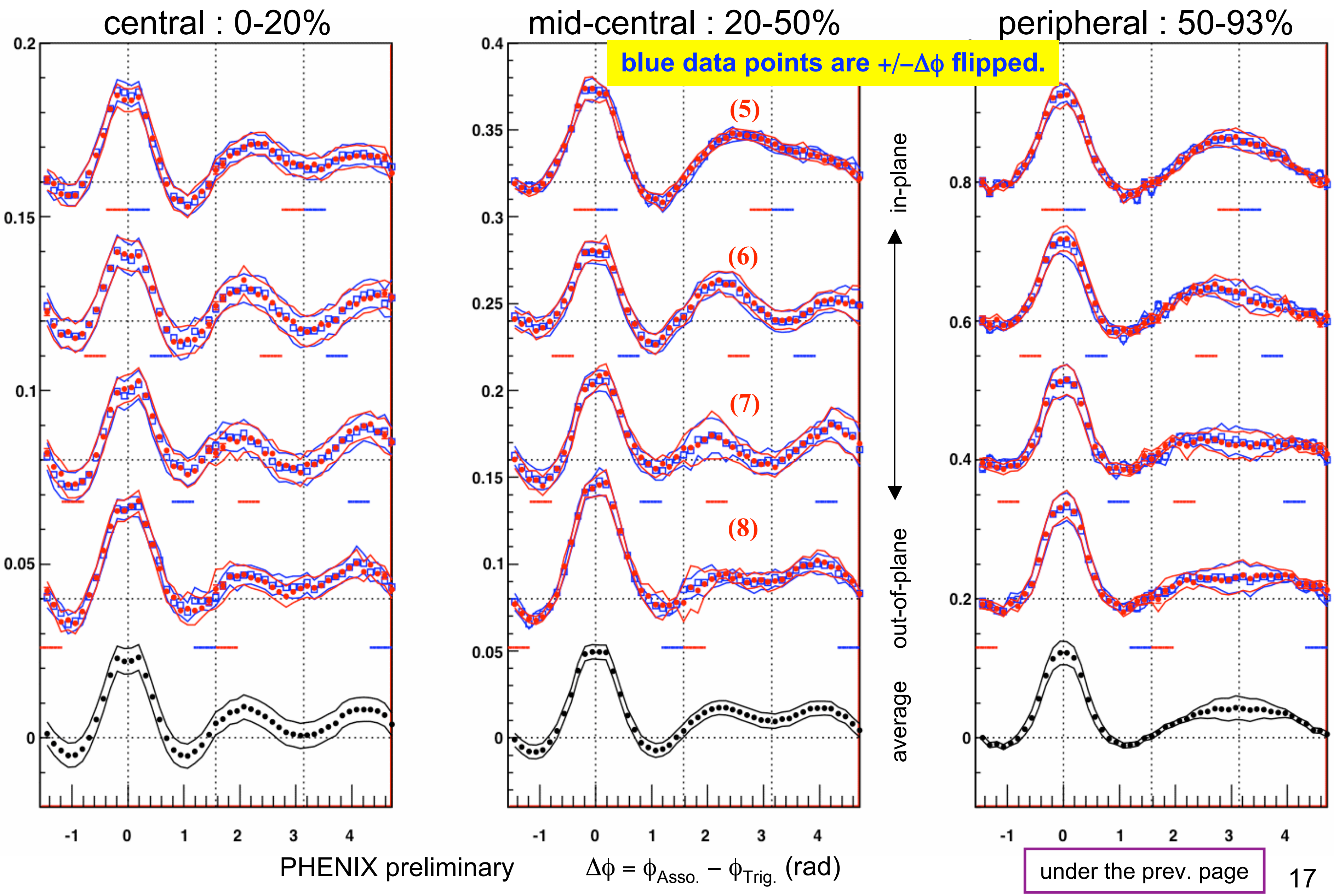




For negative trigger angle selections (1) ~ (4), $\Delta\phi$ are +/– flipped, where $-\Delta\phi$ is plotted for blue data, so that they should overlap with positive trigger selections because of the expected mirror symmetry.

turn the page!

200GeV Au+Au -> h-h (run7)(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)



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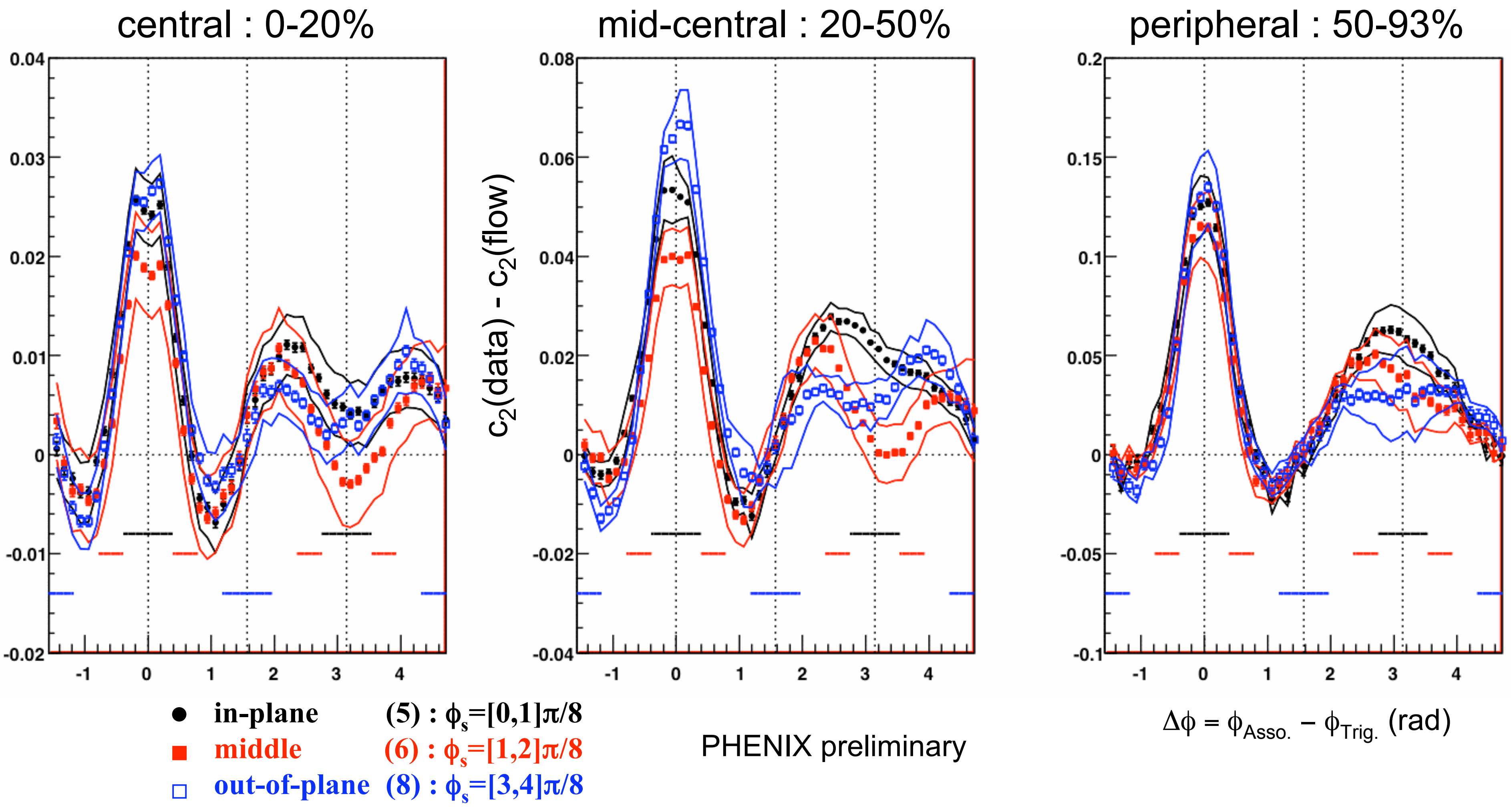
Summary Data for Left/right asymmetry

200GeV Au+Au -> h-h (run7)
(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)



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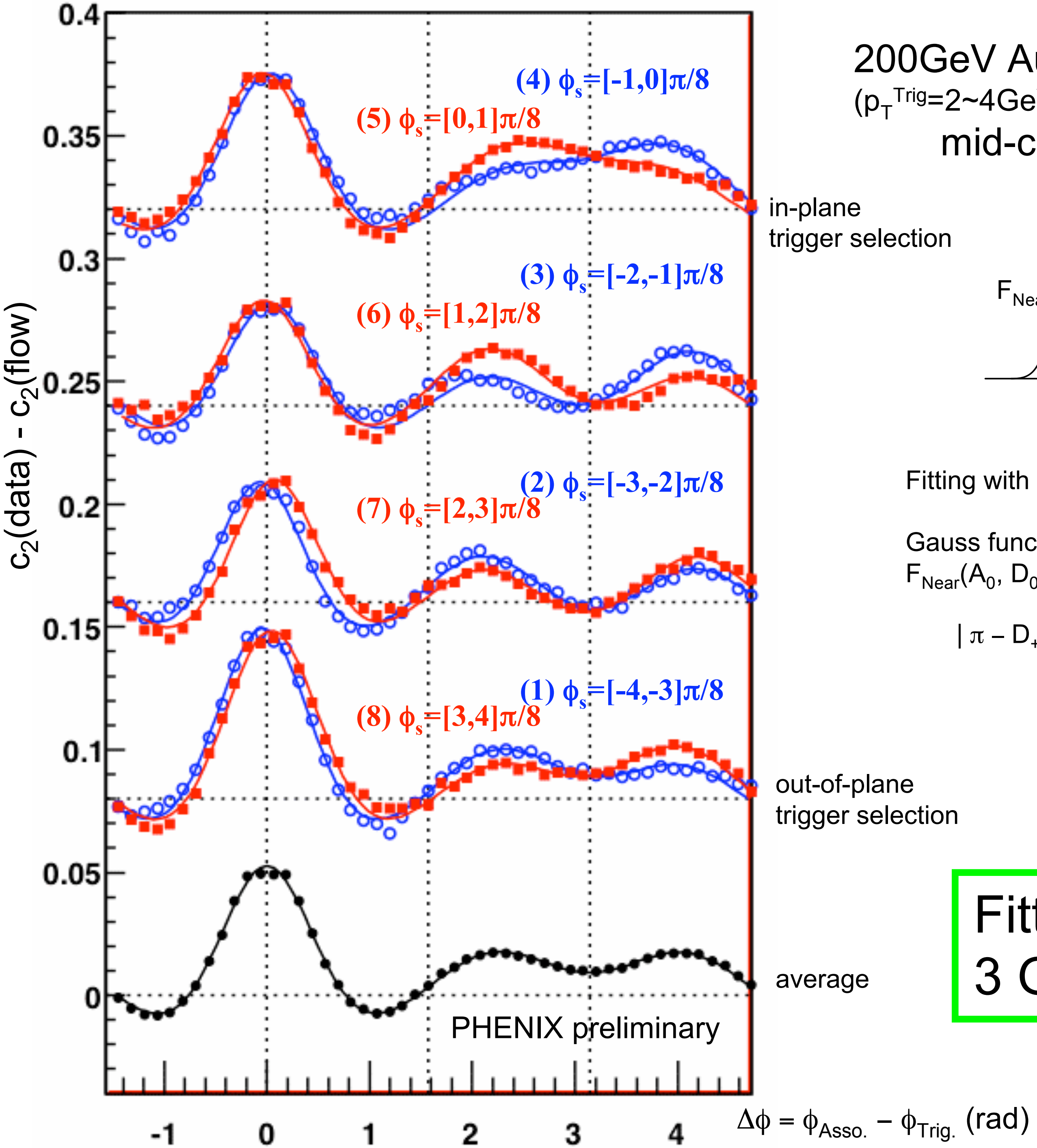
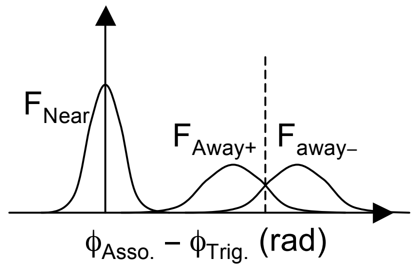


200GeV Au+Au -> h-h (run7)

(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)

mid-central : 20-50%



Fitting with 3 Gaussian functions

Gauss function : F(height, mean, width)

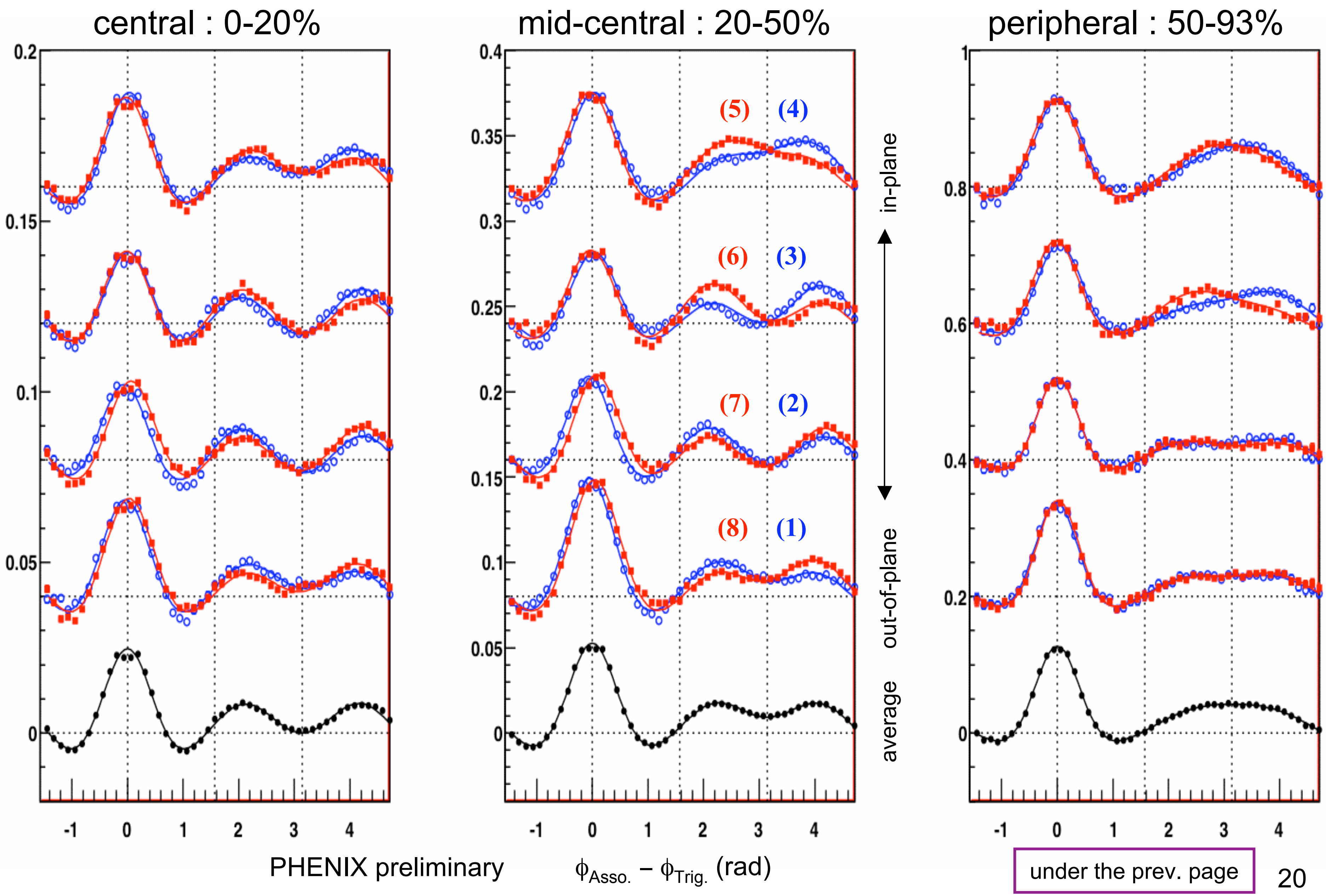
$$F_{Near}(A_0, D_0, S_0) + F_{Away+}(A_+, D_+, S_+) + F_{Away-}(A_-, D_-, S_-)$$

$$|\pi - D_+| = |D_- - \pi|, \quad S_+ = S_-$$

Fitted data with 3 Gauss func.

turn the page!

200GeV Au+Au -> h-h (run7)(p_T^{Trig}=2~4GeV/c, p_T^{Asso}=1~2GeV/c)



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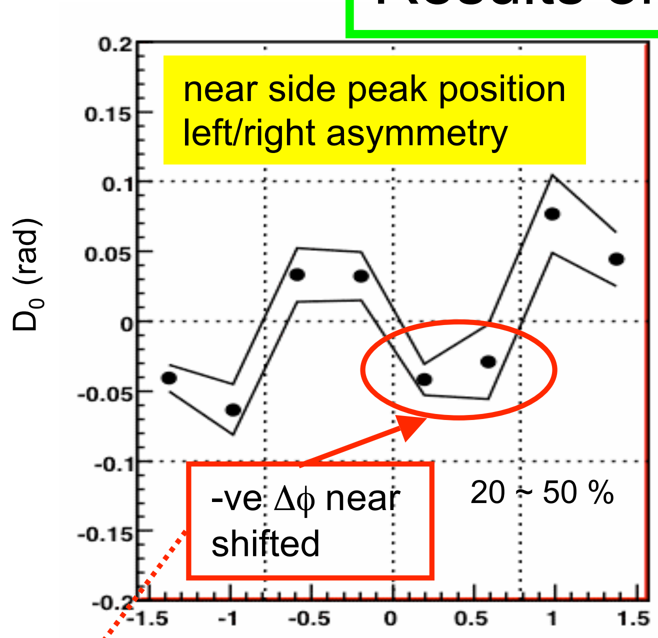
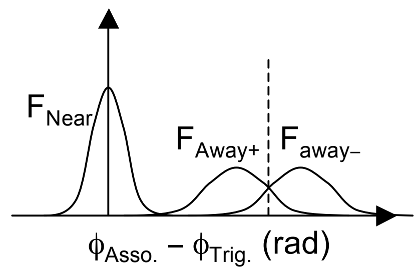
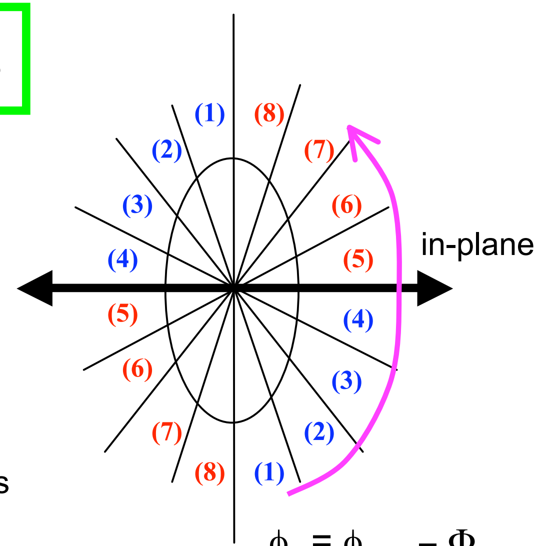
Results on fitting parameters





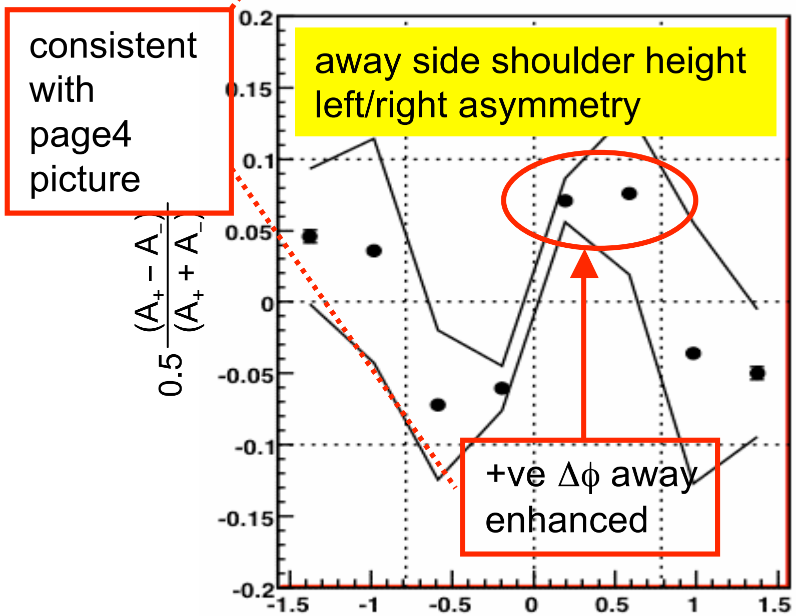


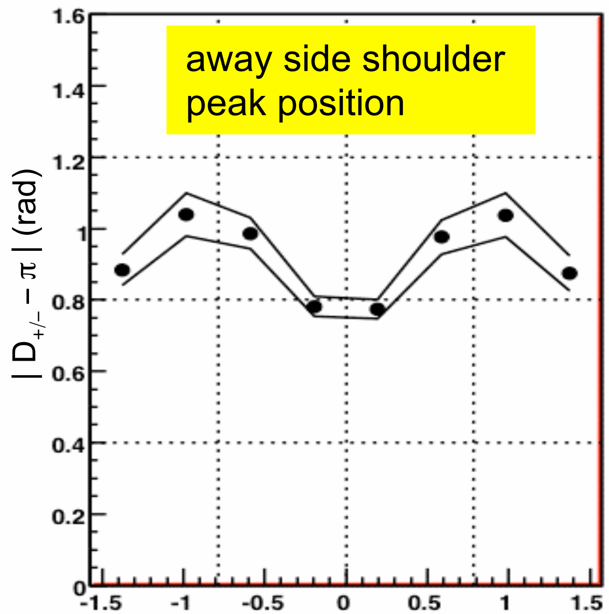
$\phi_s = \phi_{Trig.} - \Phi_{R.P.}$
$[-\pi/2, \pi/2]$

Fitting with 3 Gaussian functions

Gauss function : F(height, mean, width)

$F_{Near}(A_0, D_0, S_0) + F_{Away+}(A_+, D_+, S_+)$
$+ F_{Away-}(A_-, D_-, S_-)$
$|\pi - D_+| = |D_- - \pi|$, $S_+ = S_-$





$\phi_s = \phi_{Trig.} - \Phi_{R.P.}$ (rad)

200GeV Au+Au (run7)
hadron-hadron
(p_T^{Trig}=2~4GeV/c,
p_T^{Asso}=1~2GeV/c)

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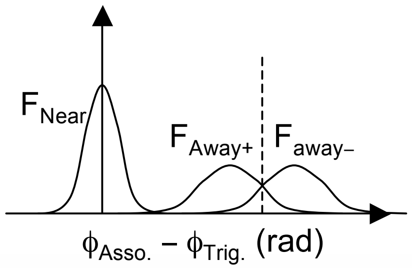
Results on fitting parameters



Gauss function : F(height, mean, width)

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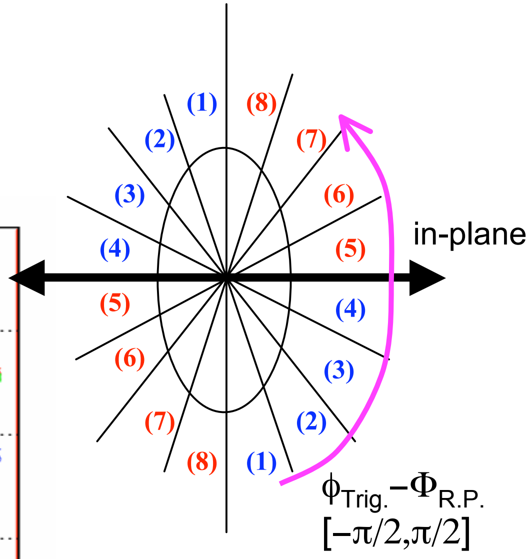

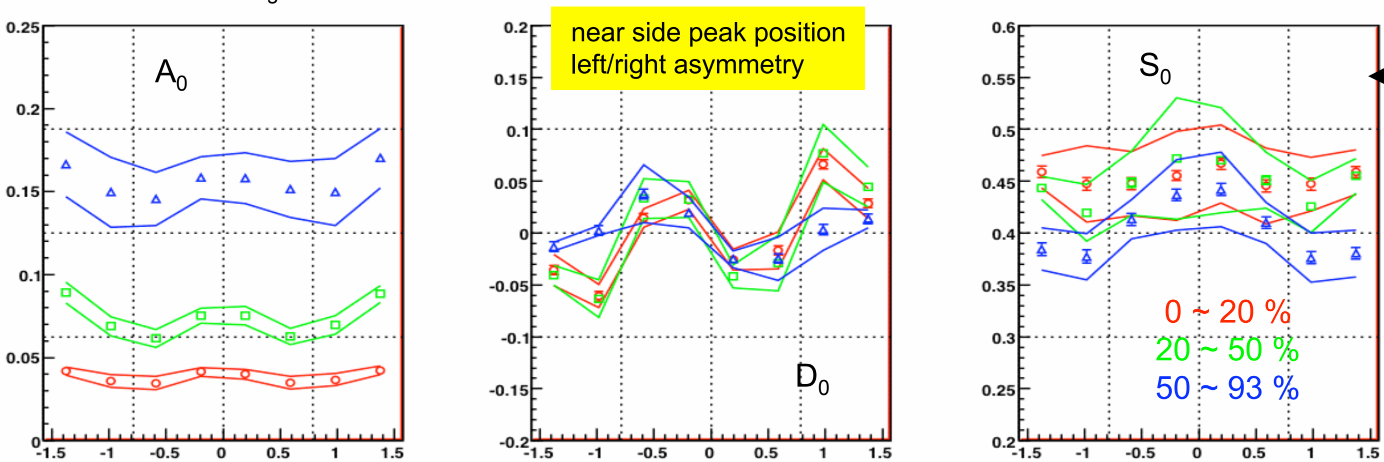

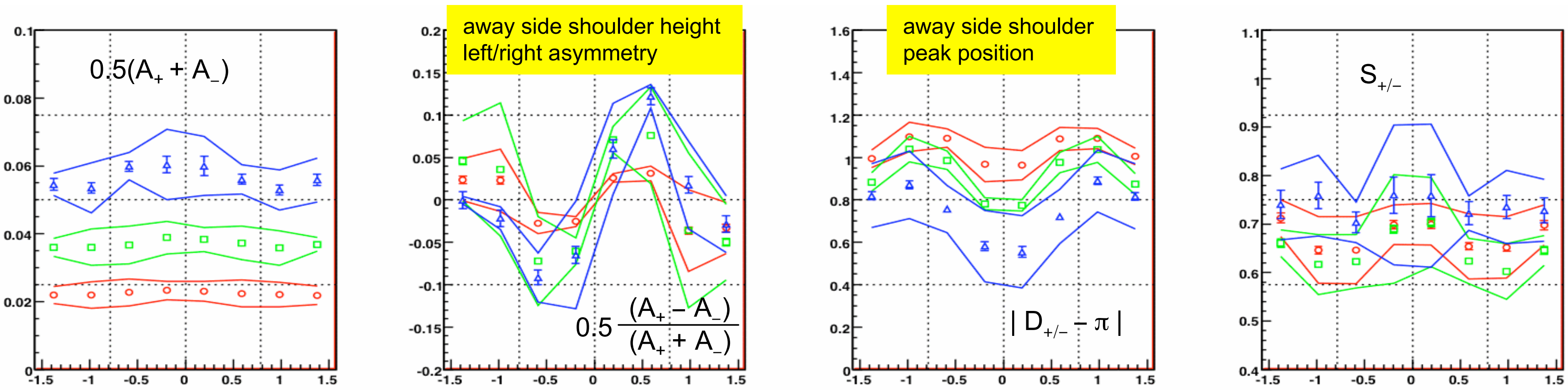

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$\phi_{Trig.} - \Phi_{R.P.}$ (rad)

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Experimental Summary

(1) modification of mach-cone like away-side shape
centrality dependence was known

(2) in-plane/out-of-plane dependence was also known

(3) left/right asymmetry of near- and away-side shape (new),
this gives a constrain to the mach-cone models

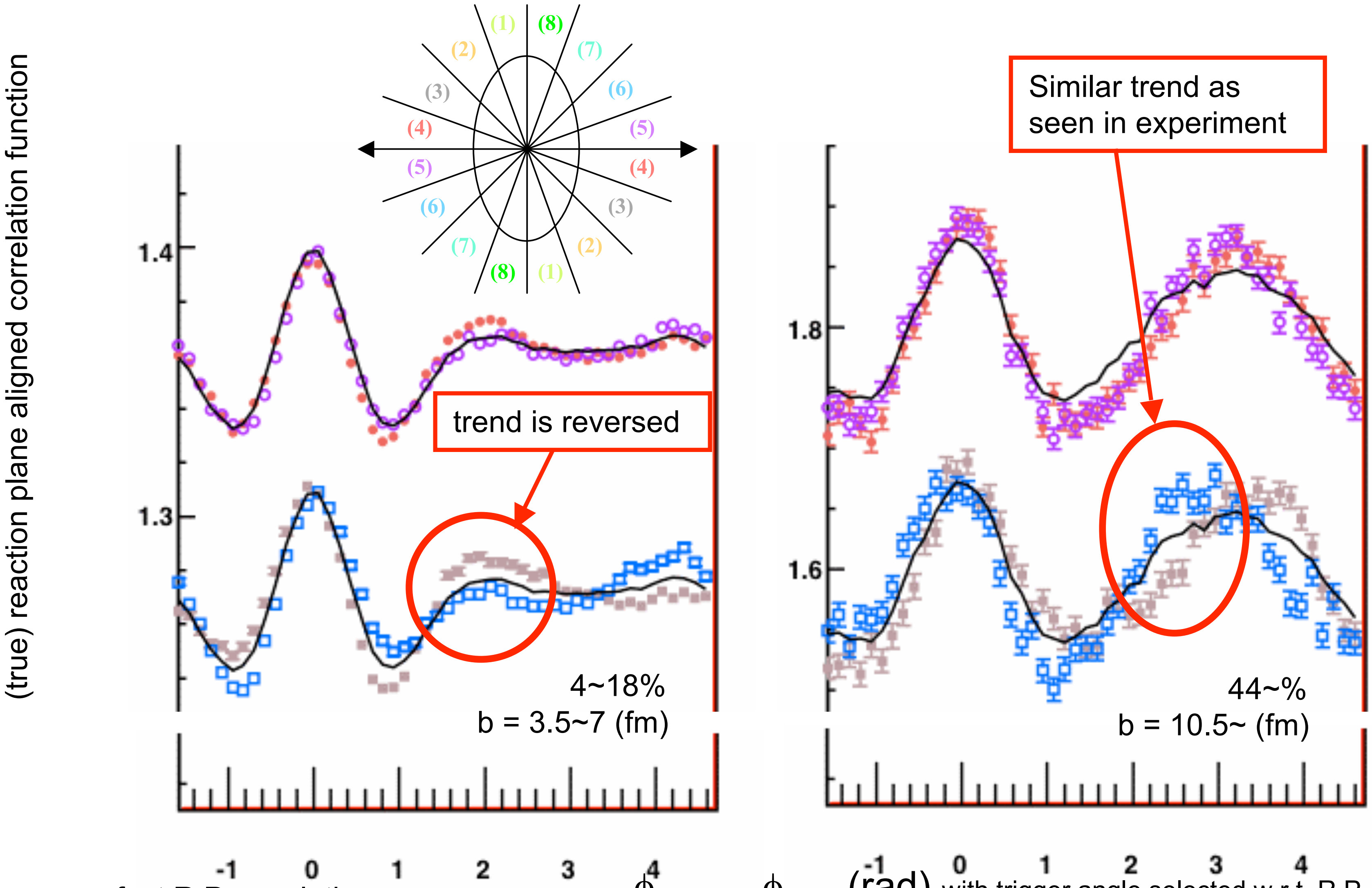
(4) implication to the inclusive v_2 and/or “true” jet bias on v_2
as well as eve-by-eve v_2 fluctuation,
positive impact on v_2 from both (2) and (3).

(5) There is no experimental way to distinguish whether
this asymmetry is caused by geometrical suppression
or by dynamical elliptic expansion. The result tells us
they are strongly coupled.

Simulation comparison slides continue …

AMPT

AMPT (v1.11, parton cascade with string melting v2.11) Au+Au at sqrt(s_{NN})=200GeV



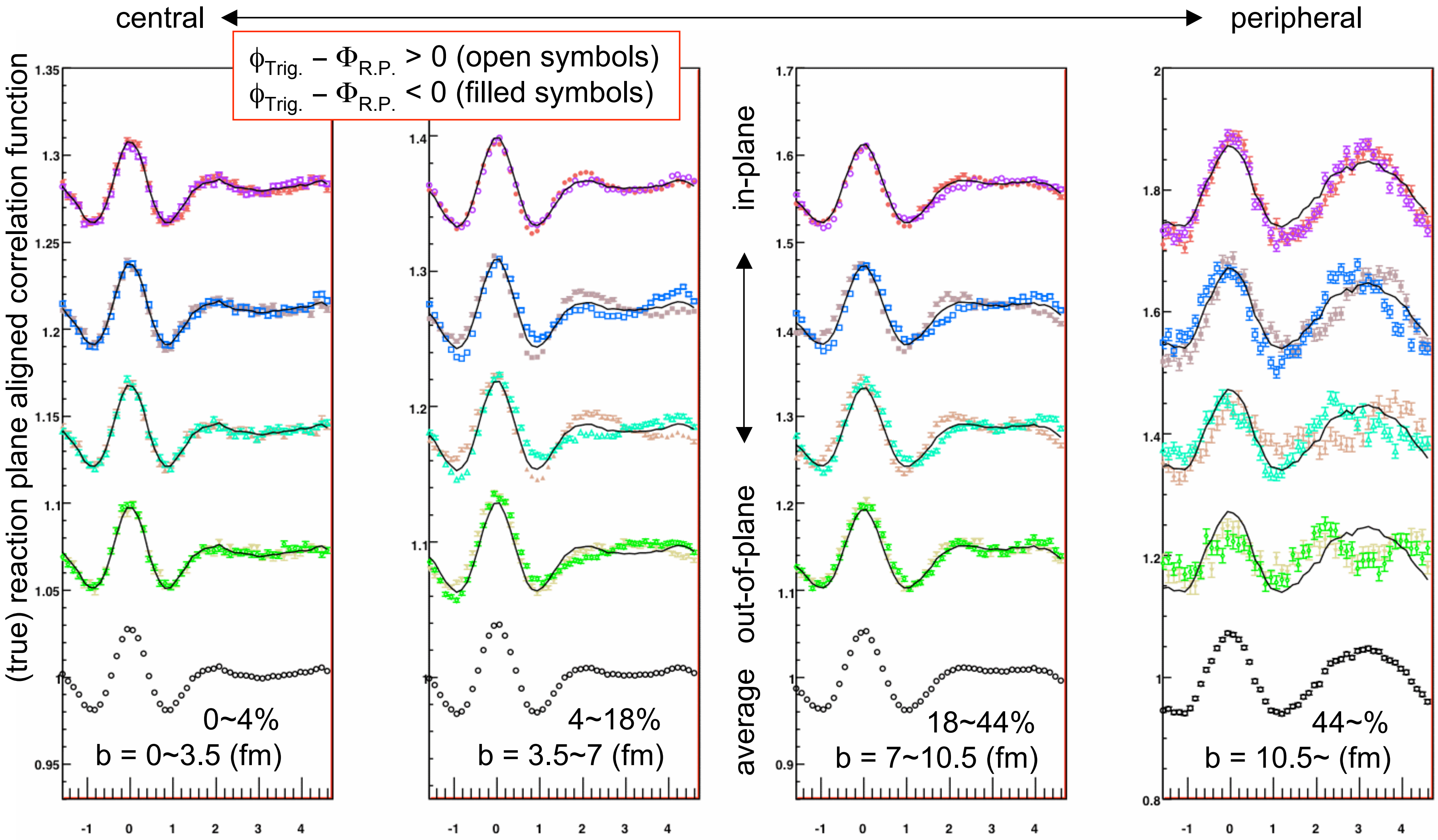
$\phi_{Asso.} - \phi_{Trig.}$ (rad) with trigger angle selected w.r.t. R.P.

perfect R.P. resolution
no v_2 subtraction needed

turn the page!

AMPT

AMPT (v1.11, parton cascade with string melting v2.11) Au+Au at sqrt(s_{NN})=200GeV



perfect R.P. resolution
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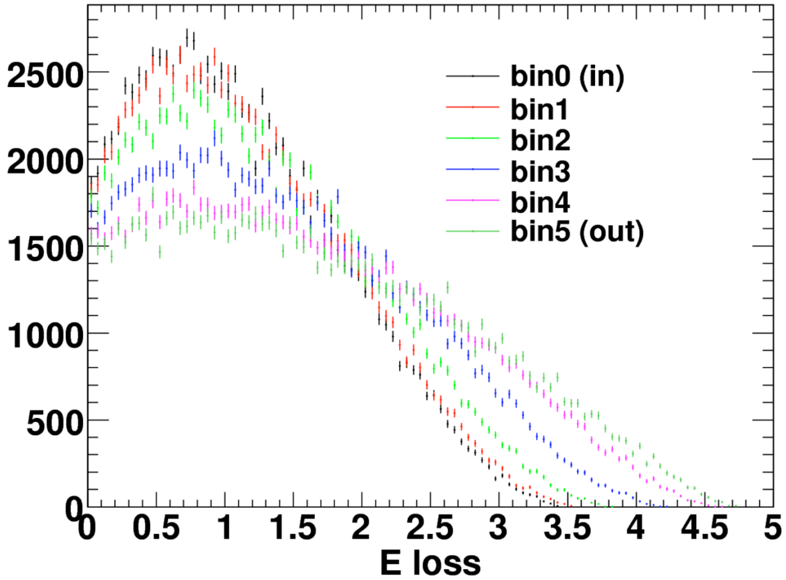
$\phi_{Asso.} - \phi_{Trig.}$ (rad) with trigger angle selected w.r.t. R.P.

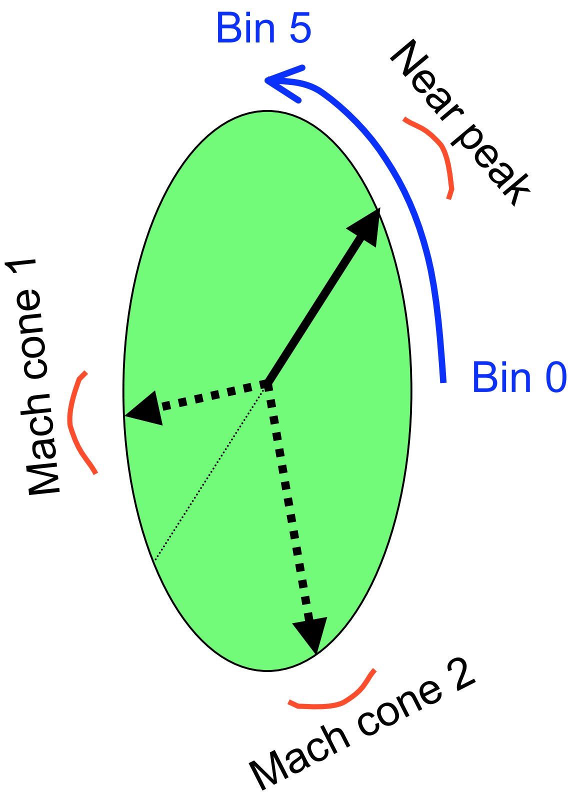
under the prev. page

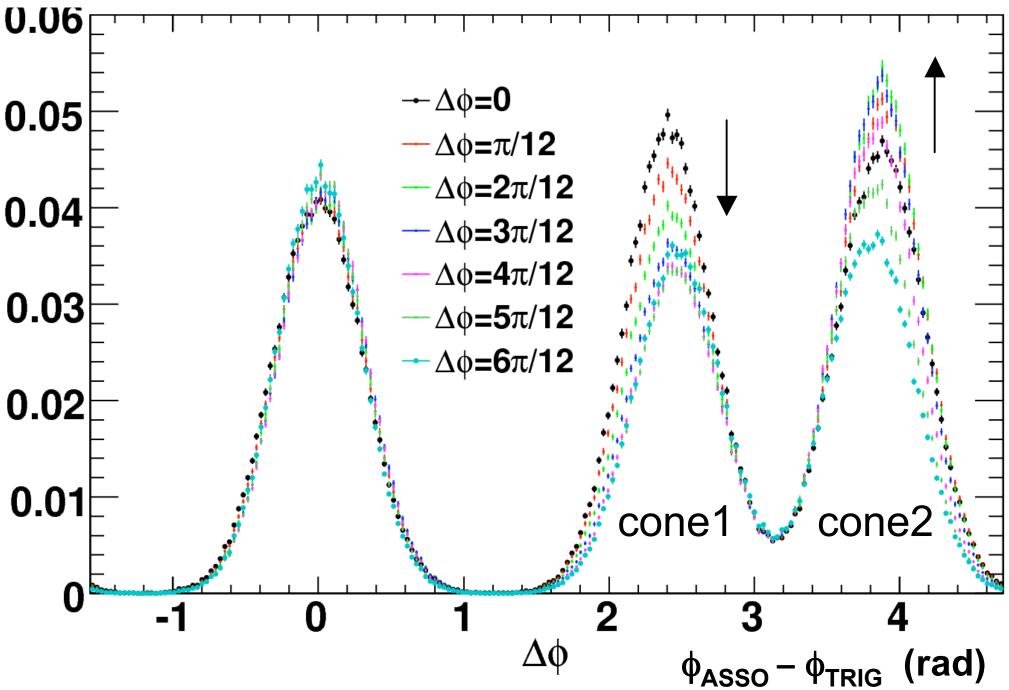
J.Jia, R.Wei, S.E
arXiv:0903.3263

Energy loss and/or absorption model

E_{loss} depending on angle w.r.t. R.P. for near peak and Mach cone 1/2







The multiplicities in these regions are assumed to be proportional to the path length (a la energy loss).

Note: original jets are generated according to N_{coll} profile

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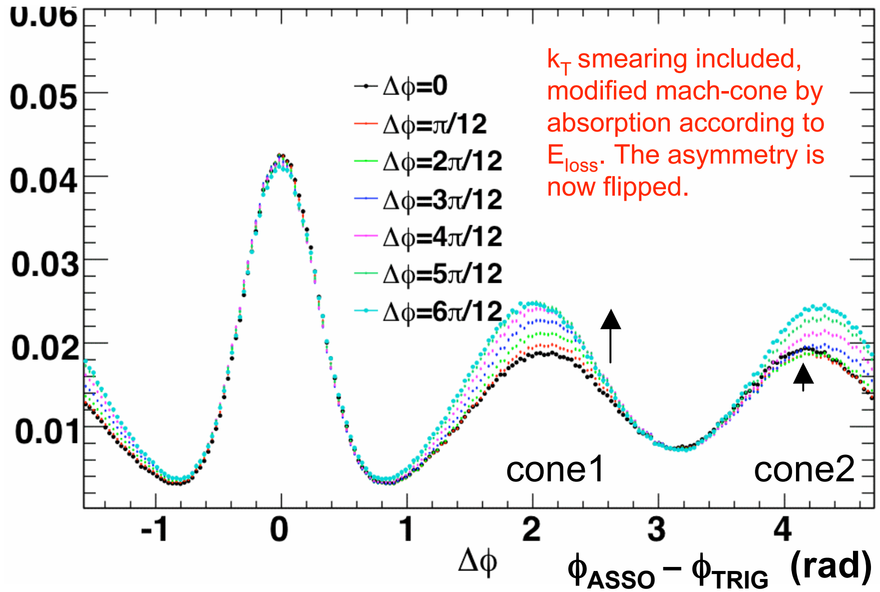
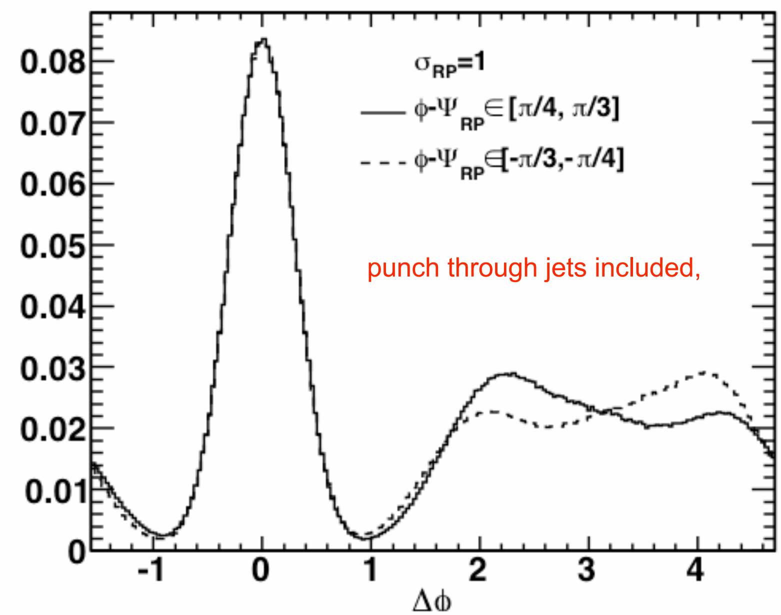
J.Jia, R.Wei, S.E
arXiv:0903.3263

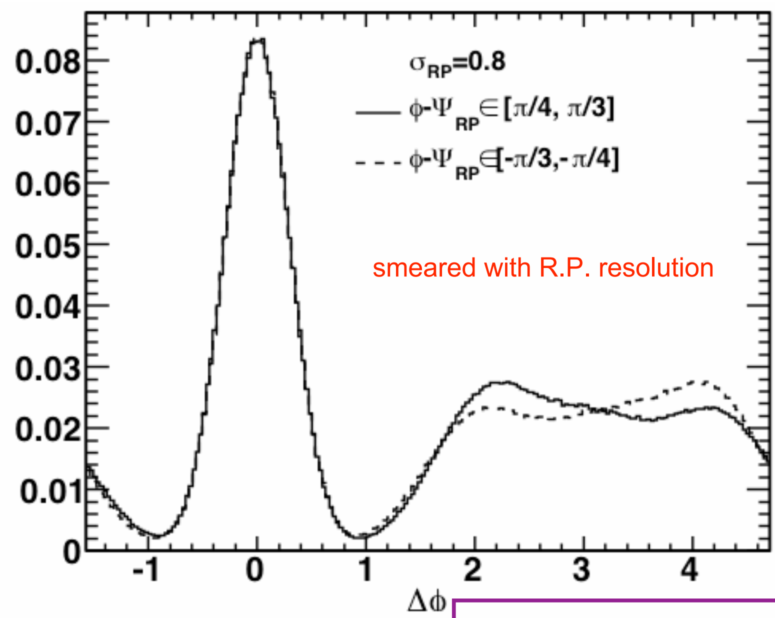
Energy loss and/or absorption model



If the multiplicities reduces with the path length because of absorption...

Note: original jets are generated according to N_{coll} profile





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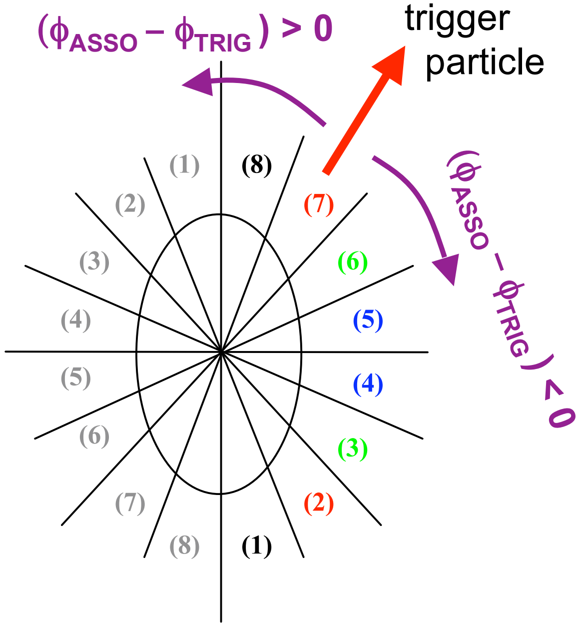
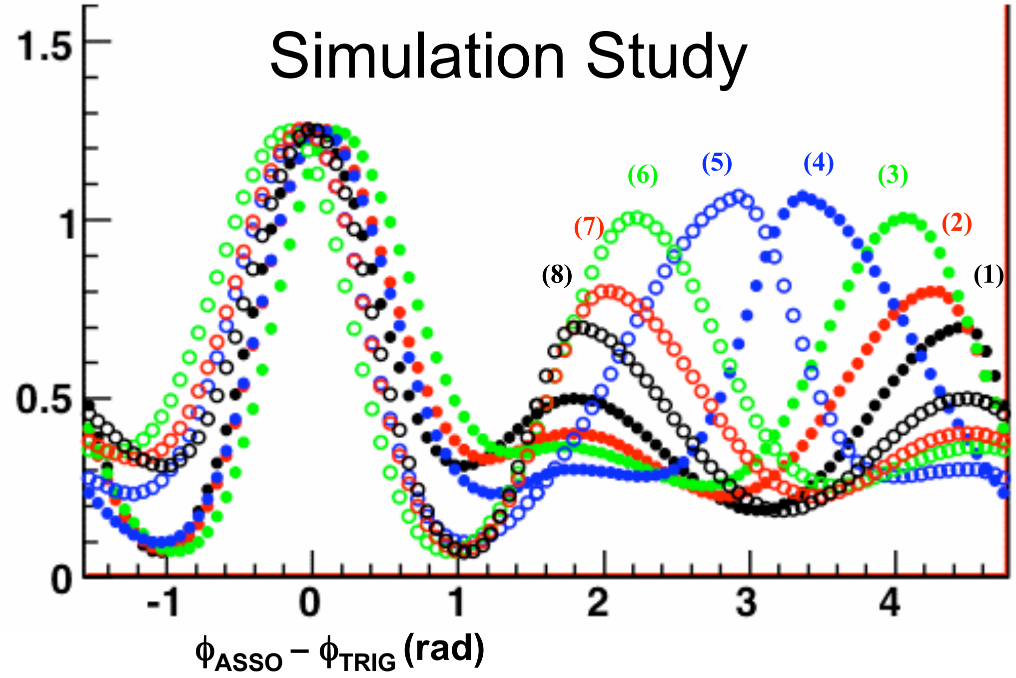




shape(1) = $f_1(x)$
shape(2) = $f_2(x)$
shape(3) = $f_3(x)$
shape(4) = $f_4(x)$
shape(5) = $f_5(x) = f_4(-x)$
shape(6) = $f_6(x) = f_3(-x)$
shape(7) = $f_7(x) = f_2(-x)$
shape(8) = $f_8(x) = f_1(-x)$

3 x (peak, left and right width)
+ 2 x relative height = 11 par

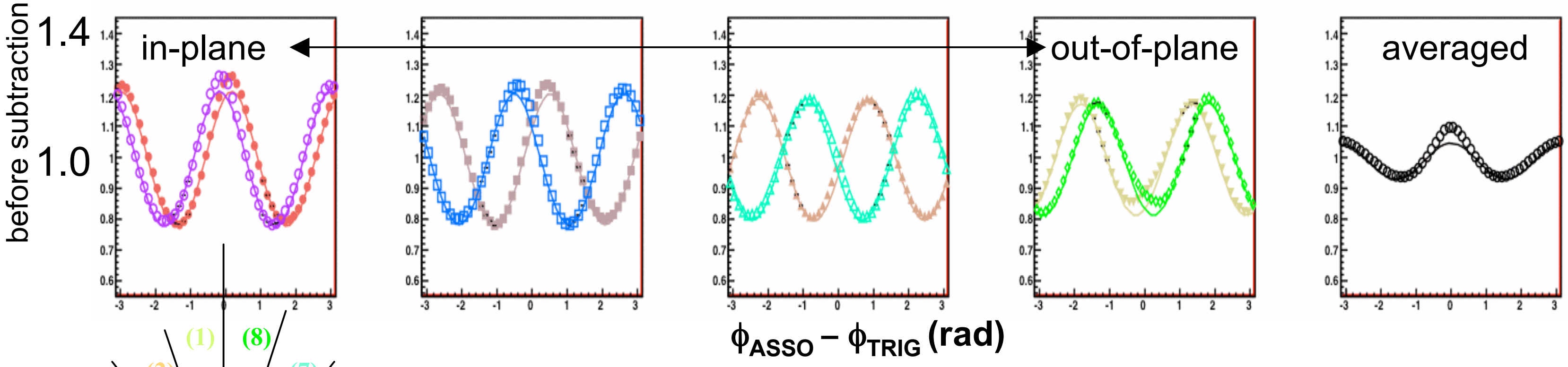
Assume very strong R.P. dependence on jet shape.

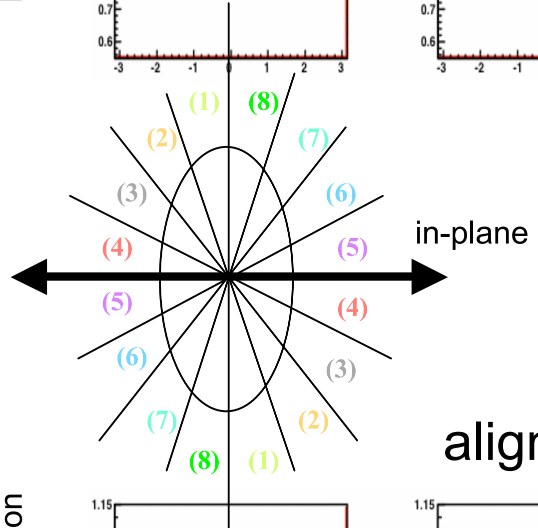
This will **NOT** be a pure non-flow. Since the assumed modification here always prefer in-plane emission than out-of-plane emission, which could be given by geometry or by elliptic expansion (azimuthal dependence of radial flow). This could also be a strong contribution to v_2 depending on the relative yield and the magnitude of the shape modification. ZYAM level might also be different from left/right averaged one.

turn the page!

Simulation

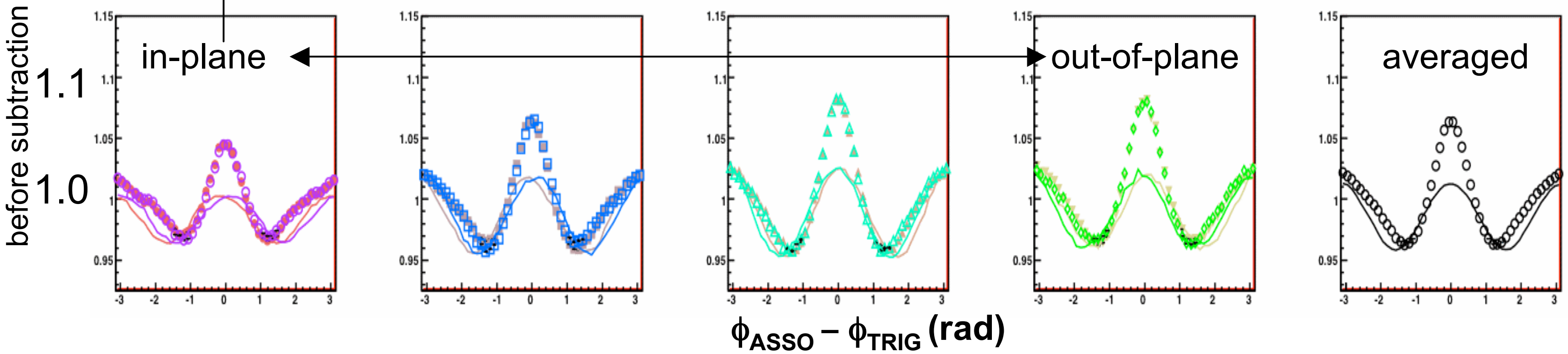
random R.P. mixing (total flow + jet)





2-particle correlation : before subtraction

aligned R.P. mixing (reduced flow + jet)



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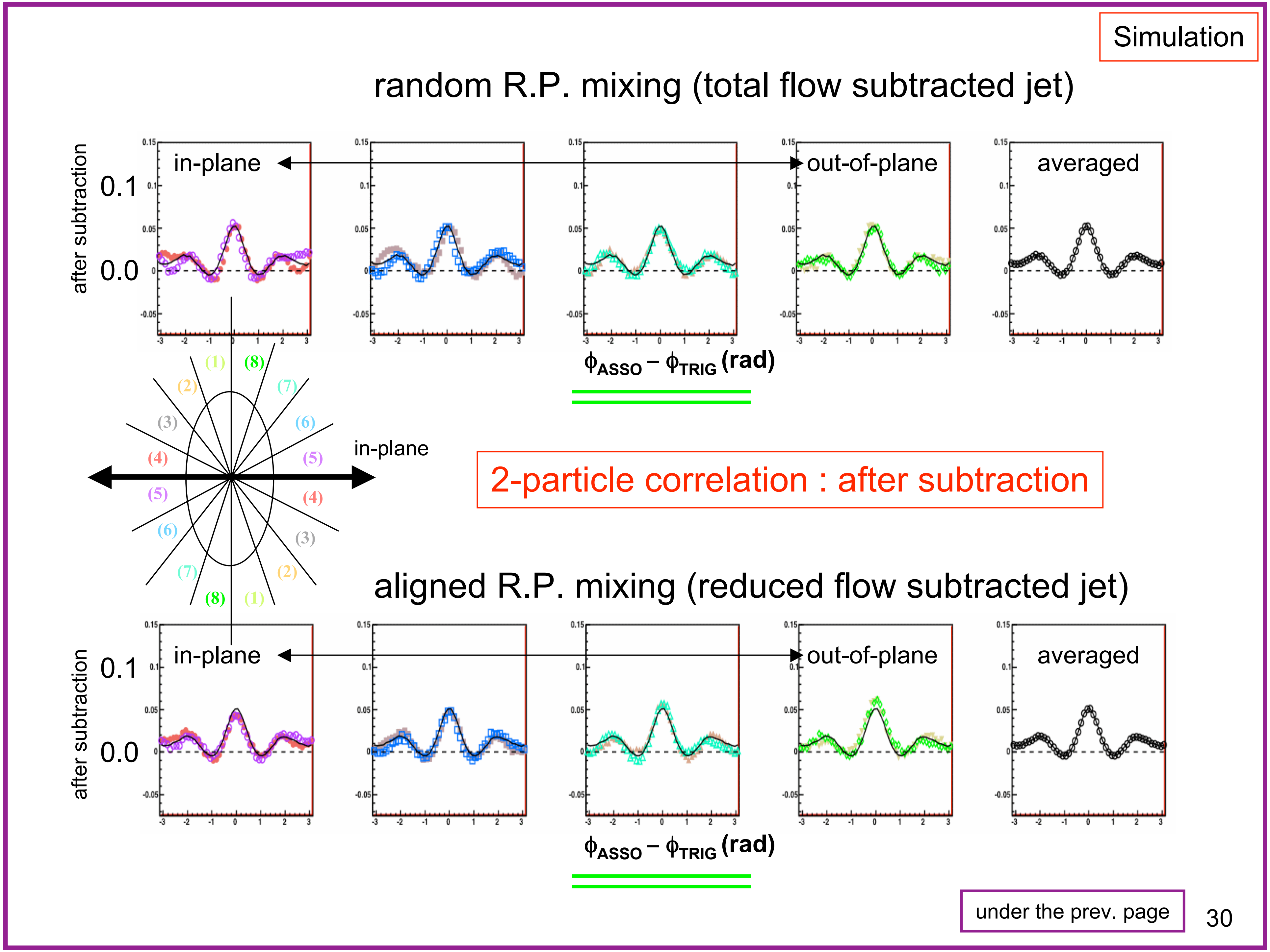
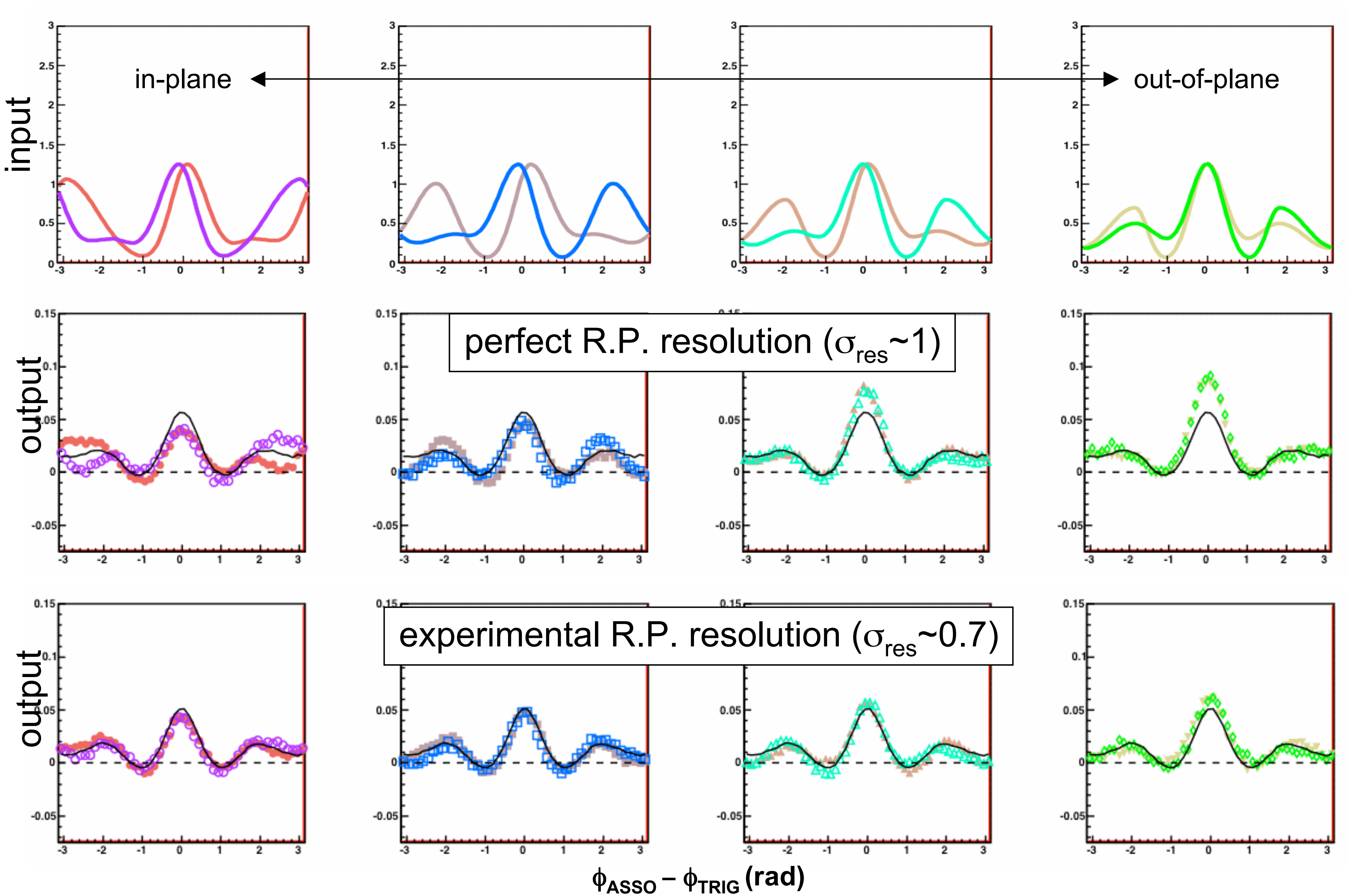

Simulation
random R.P. mixing (total flow subtracted jet)
after subtraction
0.1
0.0
in-plane
out-of-plane
averaged
$\phi_{ASSO} - \phi_{TRIG}$ (rad)
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
in-plane
2-particle correlation : after subtraction
aligned R.P. mixing (reduced flow subtracted jet)
after subtraction
0.1
0.0
in-plane
out-of-plane
averaged
$\phi_{ASSO} - \phi_{TRIG}$ (rad)
under the prev. page
30

comparison between input and output

Simulation

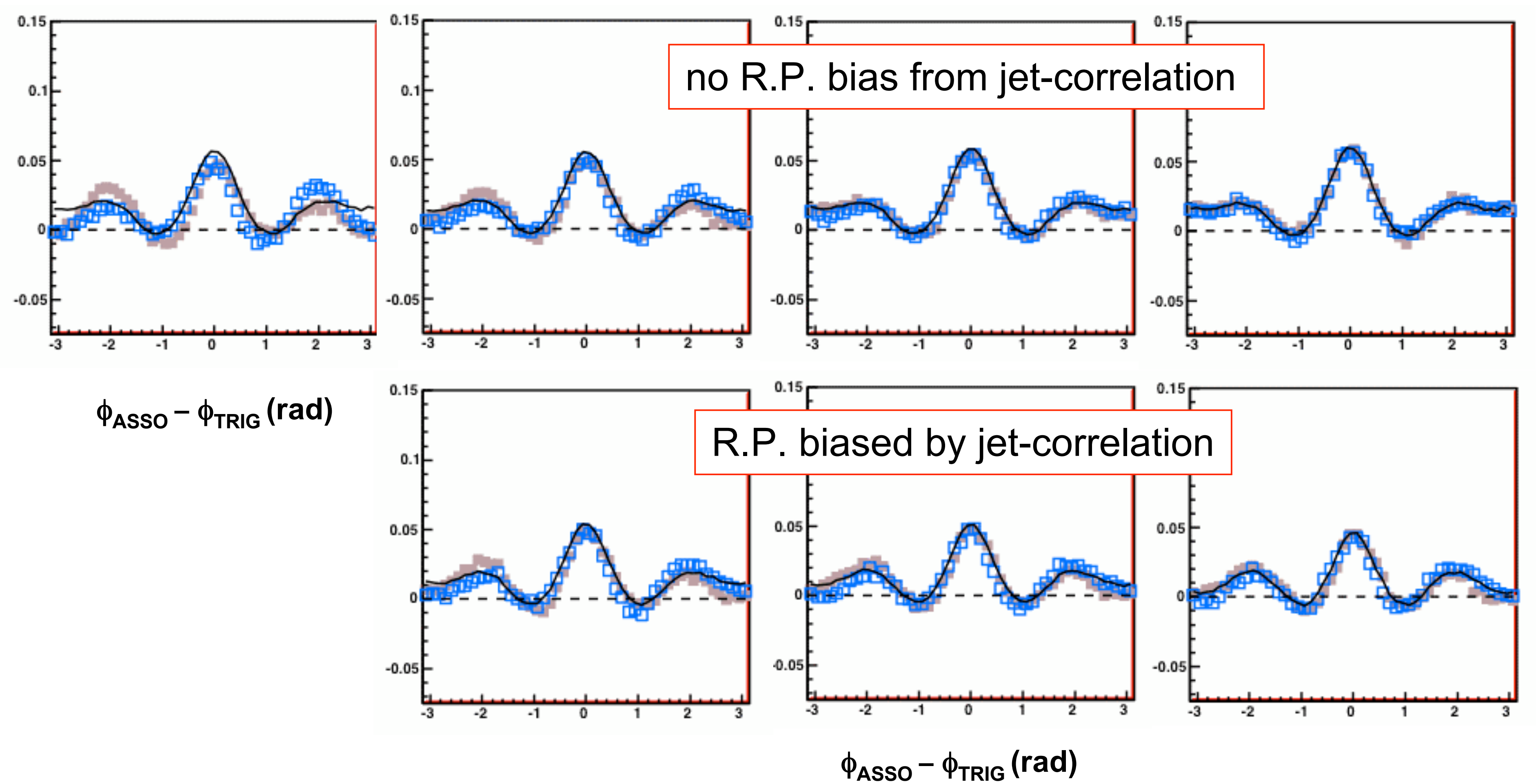


turn the page!

Simulation

effect of the experimental resolution

σ_{res}~1 σ_{res}~0.9 σ_{res}~0.7 σ_{res}~0.5



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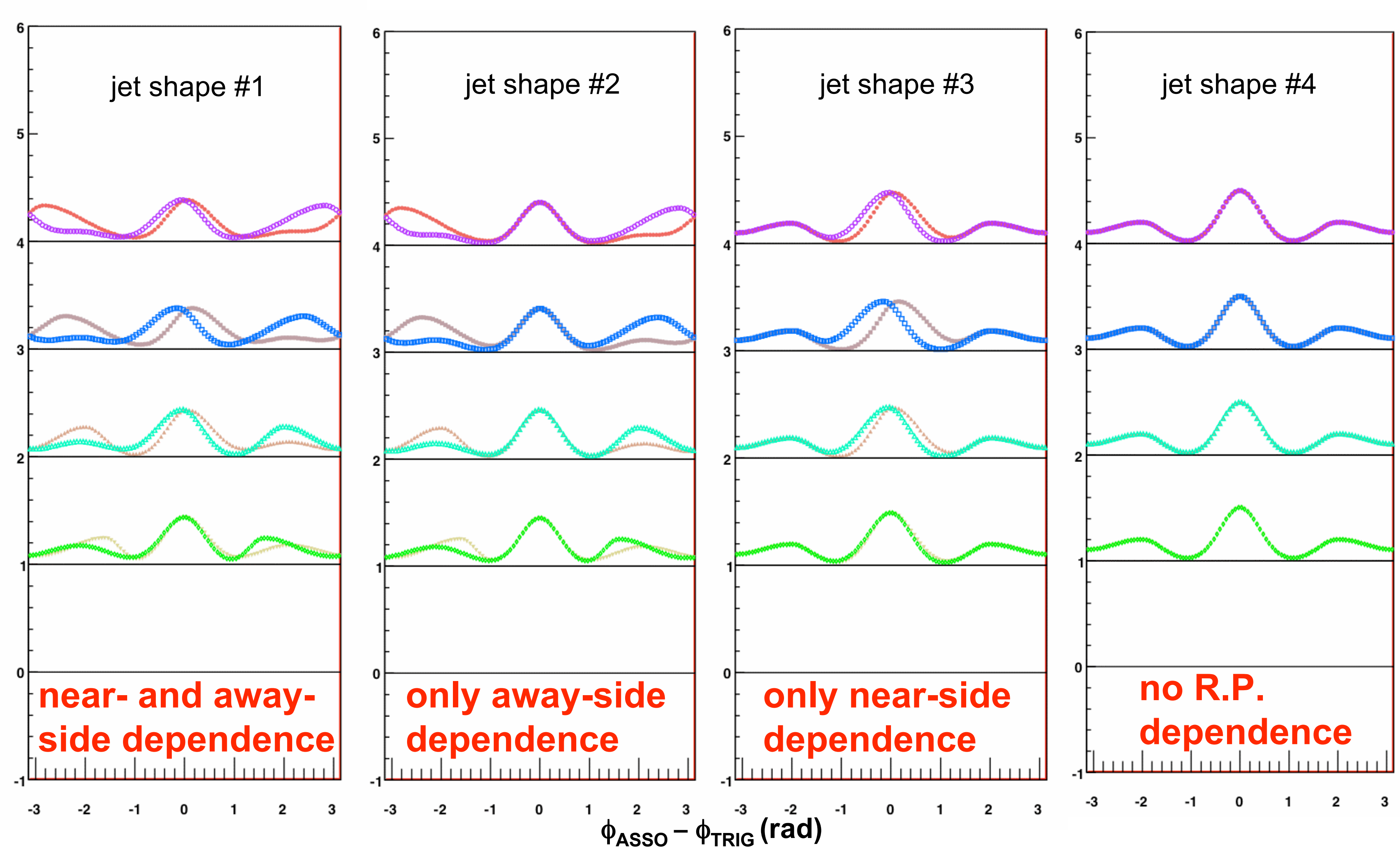
Simulation

4 different jet shape assumptions for MC input



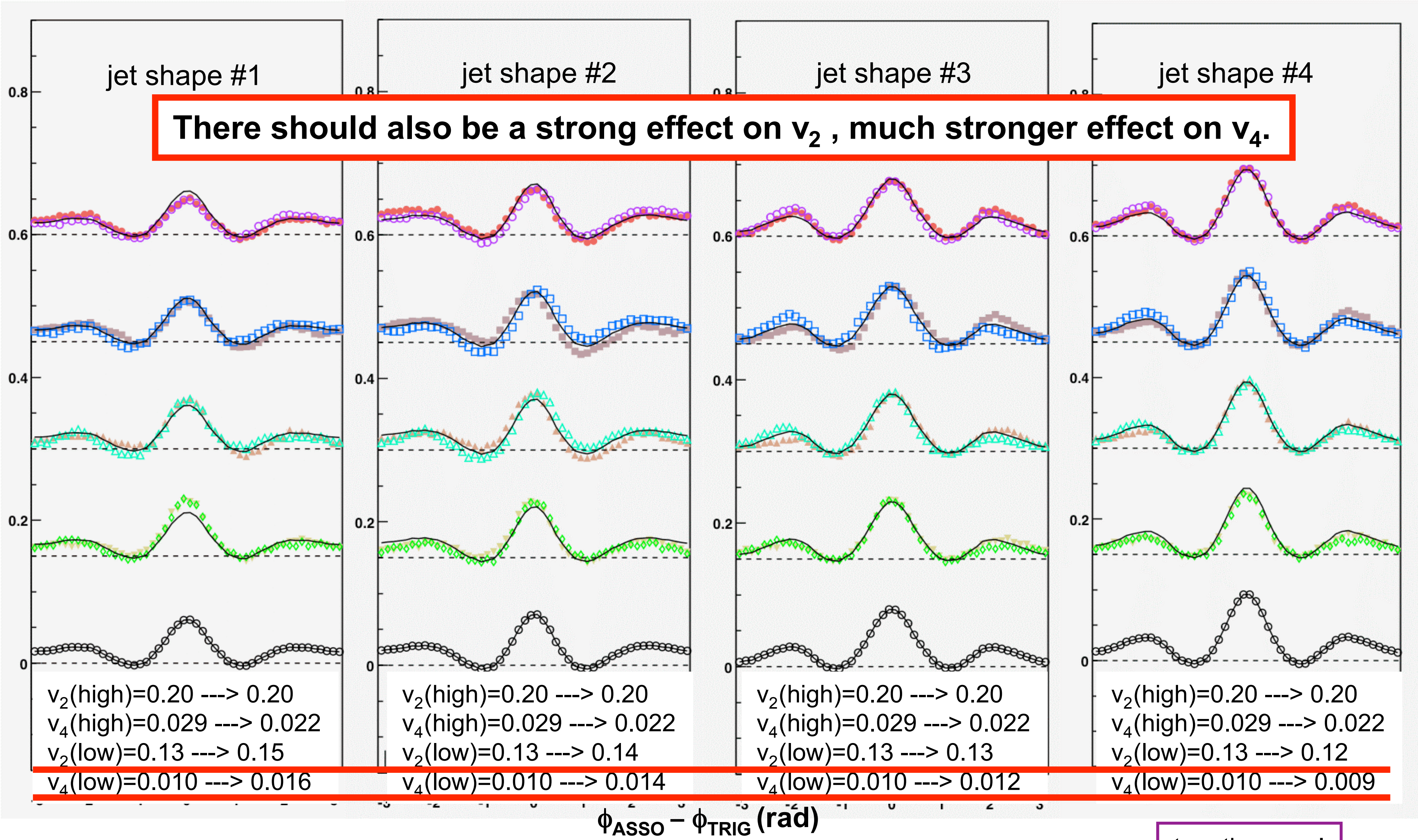
Simulation

n_{Trig} / eve (soft) = 3
n_{Asso} / eve (soft) = 8
n_{Jet} / eve (hard) = 1
n_{PTY} / jet (hard) = 1.25

$v_{2,4}^{Trig}$ (soft) = 0.2, 0.029
$v_{2,4}^{Asso}$ (soft) = 0.13, 0.010
$v_{2,4}^{Jet}$ (hard) = 0.2, 0.0
$v_{2,4}^{PTY}$ (hard) = 0.15, 0.0

Comparison with data would tell us that there should be near- and away-side modification in experimental data.

There should also be a strong effect on v_2 , much stronger effect on v_4.



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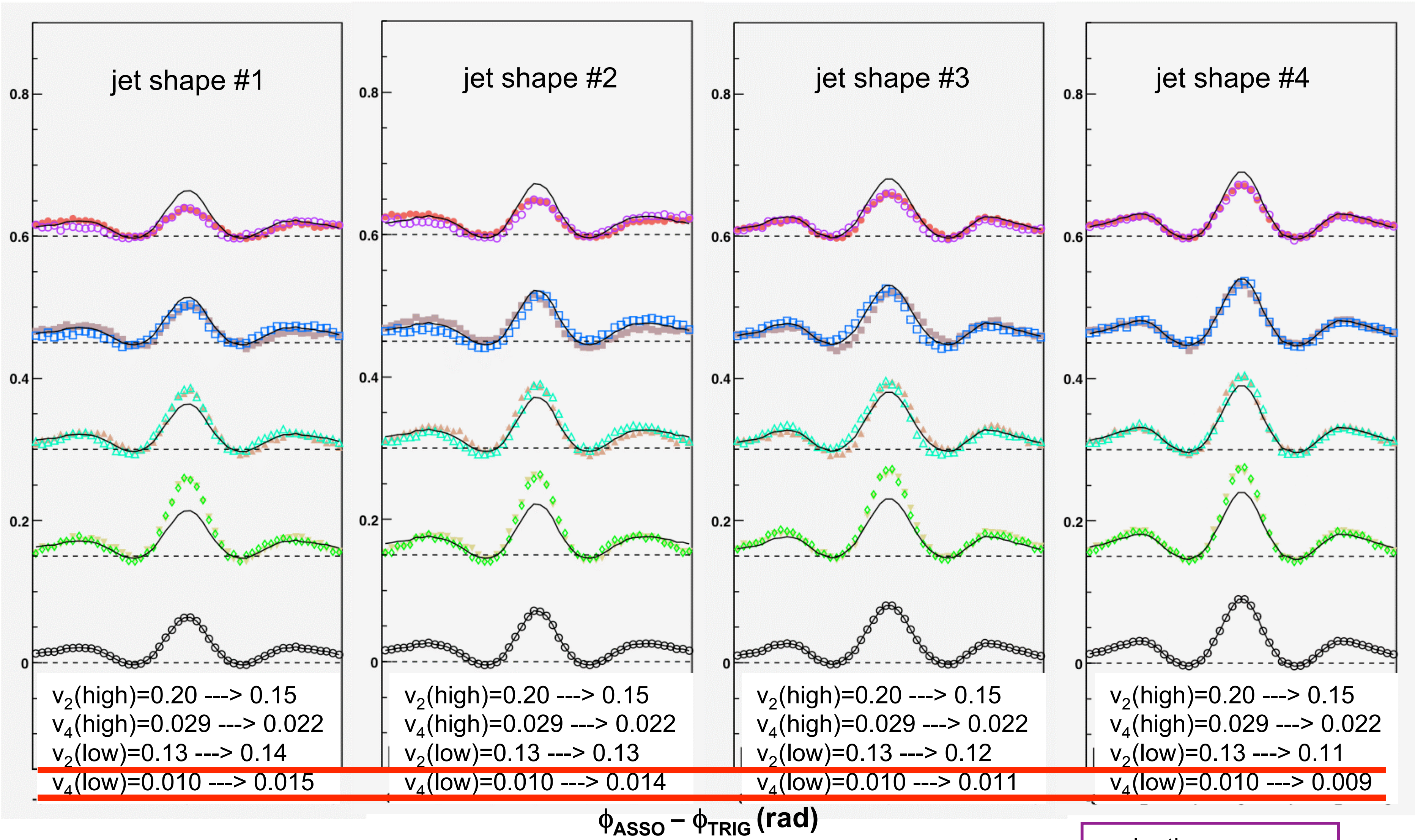
Simulation

n_{Trig} / eve (soft) = 3
n_{Asso} / eve (soft) = 8
n_{Jet} / eve (hard) = 1
n_{PTY} / jet (hard) = 1.25

$v_{2,4}^{Trig}$ (soft) = 0.2, 0.029
$v_{2,4}^{Asso}$ (soft) = 0.13, 0.010
$v_{2,4}^{Jet}$ (hard) = 0.0, 0.0
$v_{2,4}^{PTY}$ (hard) = 0.0, 0.0



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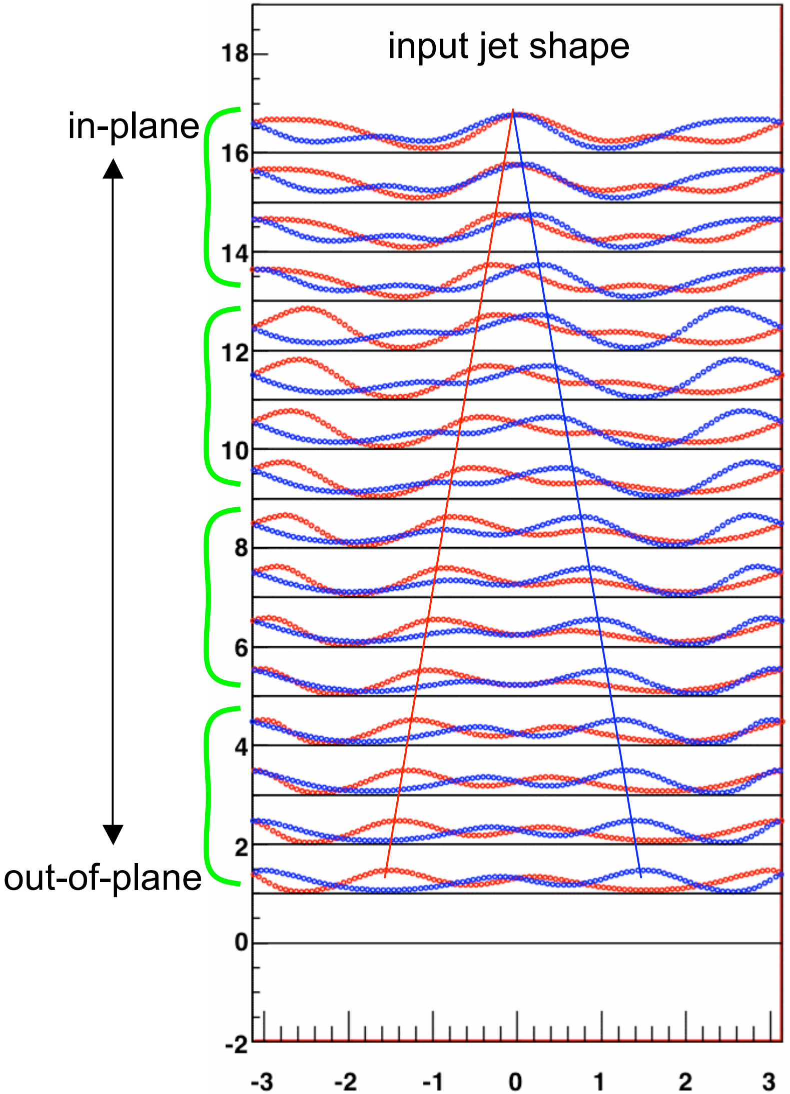
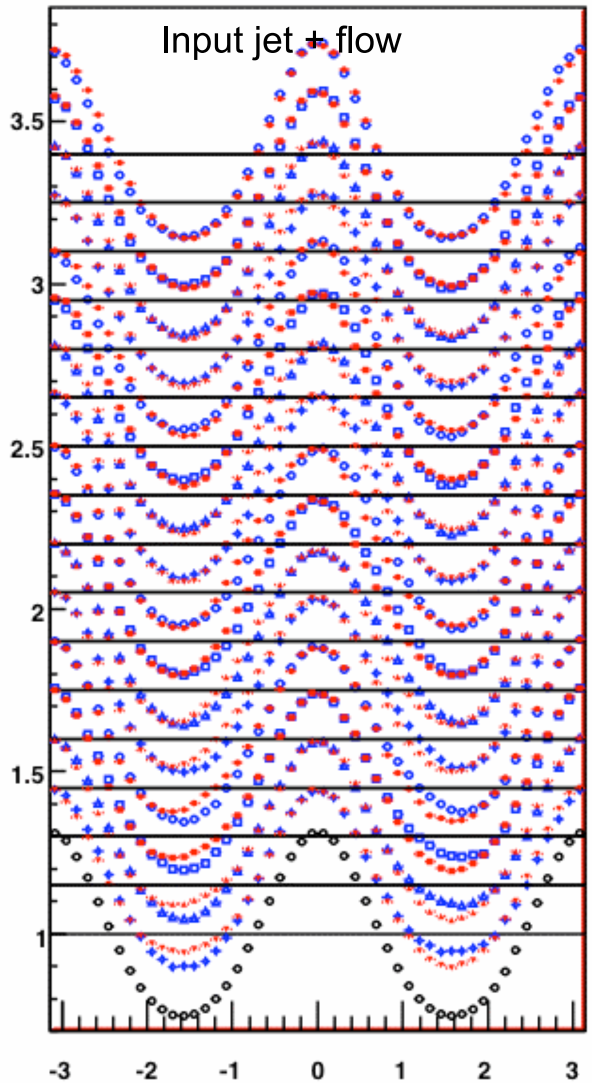
Yet another way of looking at the same data, "jet and event shape" correlation.

Simulation





Input parameters

(1) Jet shape (11x4)
(2) $v_{2,4}^{Trig}$ (soft)
(3) $v_{2,4}^{Asso}$ (soft)
(4) $v_{2,4}^{Jet}$ (hard)
(5) $v_{2,4}^{PTY}$ (hard)
(6) n_{Trig} / eve (soft)
(7) n_{Asso} / eve (soft)
(8) n_{Jet} / eve (hard)
(9) n_{PTY} / jet (hard)

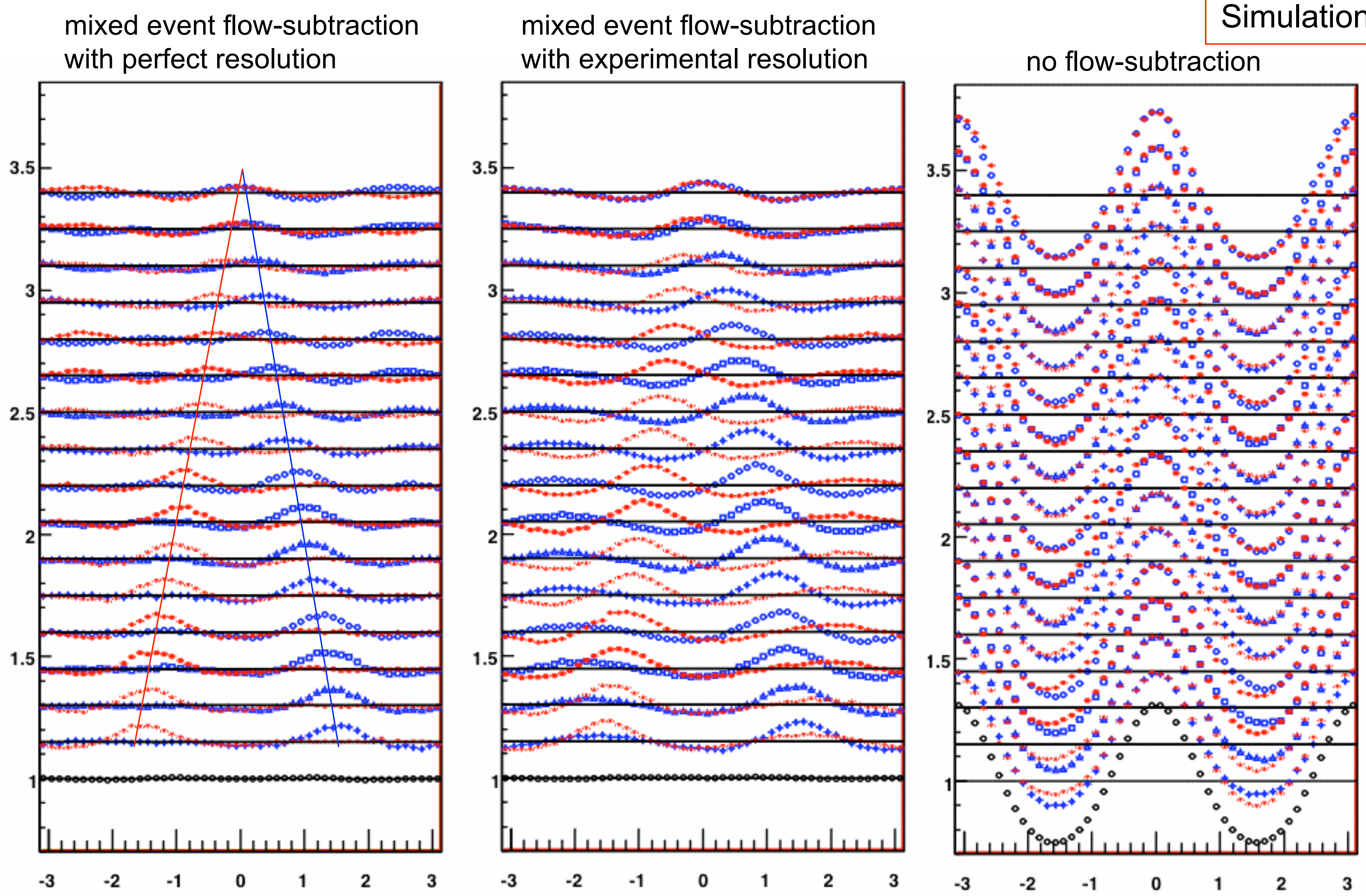
Output parameters

(a) $v_{2,4}^{Trig}$ (incl)
(b) $v_{2,4}^{Asso}$ (incl)
(c) n_{Trig} / eve (incl)
(d) n_{Asso} / eve (incl)
(e) hard/soft frac.
(true frac.)
(zyam frac.)

$\phi_{Asso} - \Phi_{R.P.}$ (trigger angle ϕ_{Trig} selection w.r.t. R.P., where ϕ_{Trig} gives the sign of 2nd order $\Phi_{R.P.}$)

turn the page!

Simulation



$\phi_{Asso} - \Phi_{R.P.}$ (trigger angle ϕ_{Trig} selection w.r.t. R.P., where ϕ_{Trig} gives the sign of 2nd order $\Phi_{R.P.}$)

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Simulation/Comparison Summary

(1) AMPT does show an interesting asymmetry, which is similar in peripheral region, but it has an opposite (left/right) trend in mid-central region (not discussed in arXiv:0903.2165). Jet shape modification gives a positive impact on v_2 at peripheral and a negative impact on v_2 at mid-central in AMPT, while experimental data do show mostly a positive impact on v_2. Special thanks to C.M.Ko et. al.

(2) Jet energy-loss and/or suppression model also shows an asymmetry that can be given by almond shape geometry and some attenuation or absorption of mach-cone (arXiv:0903.3263). Special thanks to J.Jia, R.Wei.

(3) Strong interplay between jet-modification and v_2 , v_4 and strong smearing of the measured shape by the reaction plane resolution are expected based on the toy model simulation, which also implies jet bias on the inclusive v_2 , v_4 and eve-by-eve v_2 fluctuation. (This is a true bias, which is different from the one so called “physics auto-correlation” via R.P.)